Ecological site DX032X01A150
Sandy (Sy) Big Horn Basin Core

Last updated: 9/03/2019
Accessed: 04/20/2024

General information

Approved. An approved ecological site description has undergone quality control and quality assurance review. It contains a working state and transition model, enough information to identify the ecological site, and full documentation for all ecosystem states contained in the state and transition model.

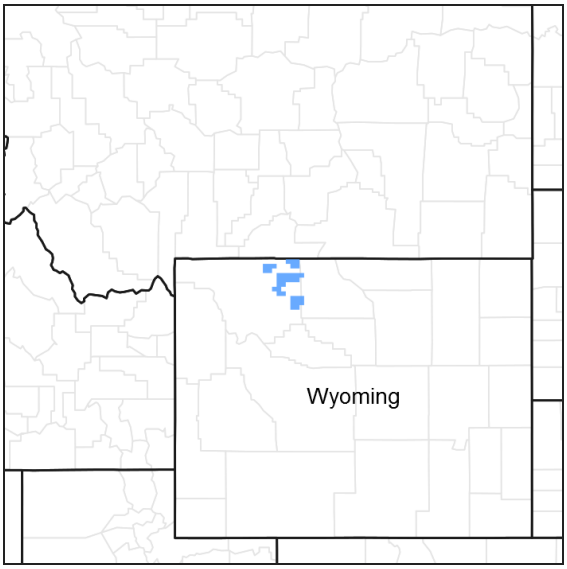


Figure 1. Mapped extent

Areas shown in blue indicate the maximum mapped extent of this ecological site. Other ecological sites likely occur within the highlighted areas. It is also possible for this ecological site to occur outside of highlighted areas if detailed soil survey has not been completed or recently updated.

MLRA notes

Major Land Resource Area (MLRA): 032X–Northern Intermountain Desertic Basins

Major land resource area (MLRA):

032X – Northern Intermountain Desertic Basins – This MLRA is comprised of two major Basins, the Big Horn and Wind River. These two basins are distinctly different and are split by land resource units (LRUs) to allow individual ecological site descriptions (ESDs). These warm basins are surrounded by uplifts and rimmed by mountains, creating a unique set of plant responses and communities. U nique characteristics of the geology and geomorphology single out these two basins.

Further information regarding MLRAs, refer to: United States Department of Agriculture, Natural Resources Conservation Service. 2006. Land Resource Regions and Major Land Resource Areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296. Available electronically at: http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/ref/?cid=nrcs142p2_053624#handbook.

LRU notes

Land Resource Unit (LRU):

32X01 (WY): This LRU is the core of the Big Horn Basin, comprised of the eroded basin floor. As the LRU shifts toward the outer edges, aspect and relation to the major bodies of water and taller landforms create minor shifts in soil chemistry influencing the variety of ecological sites and to plant interactions. The extent of soils currently correlated to this ecological site does not fit within the digitized boundary. Many of the noted soils are provisional and will be reviewed and corrected in mapping update projects. Other map units are correlated as small inclusions within other MLRAs and LRUs based on elevation, landform, and biological references.

Moisture Regime: Typic Aridic. Prior to 2012, there were map units that cross over to ustic aridic or ustic aridic was correlated into this core area. As progressive mapping continues and when the opportunity arises to do update projects, these overlapping map units will be corrected.

Temperature Regime: Mesic
Dominant Cover: Rangeland, with saltbush flats as the dominant vegetative cover for this LRU/ESD
Representative Value (RV) Effective Precipitation: 5-9 inches (127 –229 mm)
RV Frost-Free Days: 110-150 days

Classification relationships

Relationship to Other Established Classification Systems:

National Vegetation Classification System (NVC):
3 Xeromorphic Woodland, Scrub & Herb Vegetation Class
3.B Cool Semi-Desert Scrub & Grassland Subclass
3.B.1 Cool Semi-Desert Scrub & Grassland formation
3.B.1.NE Western North American Cool Semi-Desert Scrub & Grassland Division
M169 Great Basin & Intermountain Tall Sagebrush Shrubland & Steppe Macrogroup
G302 Artemisia Tridentata - Artemisia tripartita - Purshia tridentata Big Sagebrush Steppe Group
A3182 Artemisia tridentate ssp. Wyomingensis Mesic Steppe & Shrubland Alliance
CEGL001051 - Artemisia tridentata ssp. Wyomingensis/Hesperostipa comata Shrubland

Ecoregions (EPA):
Level I: 10 North American Deserts
Level II: 10.1 Cold Deserts
Level III: 10.1.18 Wyoming Basin
Level IV: 10.1.18.b Big Horn Basin (and)
10.1.18.g Big Horn Salt Desert Shrub Basin

Ecological site concept

• The Sandy ecological site (ES) receives no additional water.
• Slope is less than 20 percent

• Soils in the Sandy ES:
o have textures that range from loamy sand to very fine sandy loam in the top 4” (10 cm) of the mineral soil surface
o have a clay content that is less than or equal to 18 percent in the top 4 inches (10 cm) of the mineral soil surface
o have subsurface horizons in the particle-size control section with a weighted average of less than 18 percent clay. (The particle-size control section is the segment of the profile from either the start of an argillic horizon for 50 cms or from 25-100 cms).
o are moderately deep to very deep (20-80+ inches or 50-200+ cm)
o have less than 3 percent stone and boulder cover and less than 20 percent cobble and gravel cover
o are not skeletal (have less than 35 percent rock fragments) within 20 inches (50 cm) of the mineral soil surface
o are not effervescent or slightly effervescent throughout the top 20 inches (50 cm) of the mineral soil surface
o are non-saline, sodic or saline-sodic

The Sandy ecological site concept is based on minimal (none to slight) influence from salts, carbonates, gypsum, or other chemistry within the top 20 inches (50 cm) of the mineral soil surface. The main soil characteristic is a

moderately deep to very deep soil that has a coarse texture with less than 18 percent clay throughout the soil profile. The dominant soil textural classes are loamy fine sand to sandy loam in the subsurface. The plant community shifts away from the Sandy ecological site as the control section increases above 18 percent clays with increased rhizomatous wheatgrasses, additional forb species, and increased bare ground.

The Sandy site can be found in several different catena throughout the basin. In an escarpment catena, it occurs with shallow and very shallow soils. Hillslope catena have Sandy and Loamy ecological sites occurring in a complex mosaic pattern where the geology is controlled by interbedded sandstone and shale; or in an area where the parent material is alluvial. Sandy sites are most commonly located with sandstone bedrock and can be found in stable areas adjacent to rock outcrop. In these stable and developed (weak structure) soils, yucca, shadscale, and spiny hopsage are common and generally occur closer to rock outcrop. These shrub species are also common in the Sands ecological site, which is characterized by no or minimal soil development (single-grain structure).

Associated sites

R032XY112WY	**Gravelly (Gr) 5-9” Big Horn Basin Precipitation Zone** Gravelly sites have a higher rate of bluebunch wheatgrass, lack production that Sandy sites hold, and are higher in forbs, especially the pincushion forbs that occur on the Gravelly sites.
R032XY146WY	**Sands (Sa) 5-9” Big Horn Basin Precipitation Zone** The Sands ecological site lacks the structure and stability of the Sandy ecological site. The Sands site occurs on relatively flat locations or concave positions that collect aeolian materials. Productivity is lower and a higher diversity of forbs generally is found on this site.
R032XY104WY	**Clayey (Cy) 5-9” Big Horn Basin Precipitation Zone** The Clayey ecological site has similar production potential; however, responses to disturbance, management and climatic changes will be different. Location on the landscapes are similar, but Clayey sites tend to fall along alluvial drainages or below shale outcrops and outwashes.
R032XY122WY	**Loamy (Ly) 5-9” Big Horn Basin Precipitation Zone** Loamy sites will also be similar in production, but again response to management, disturbance, and climatic shifts will vary. Loamy sites generally are found in the central or posterior edge of a landform such as alluvial fans, fan aprons, outwashes, and pediments.
R032XY128WY	**Lowland (LL) 5-9” Big Horn Basin Precipitation Zone** The Lowland site will have similar soils, outside of the presence of a water table during parts of the year at a depth greater than 100 cms. This water table influences the vegetation, as have basin big sagebrush and other water-demanding plants.
R032XY166WY	**Shallow Sandy (SwSy) 5-9” Big Horn Basin Precipitation Zone** Shallow Sandy sites generally are located on the break of slopes, on or surrounding rock outcrops before it transitions into more gently rolling landforms with deeper soils. Similar plant communities have more pincushion forbs and a higher percentage of bluebunch wheatgrass, but a marked reduction in production and increased bare ground.

Similar sites

R032XY350WY	**Sandy (Sy) 10-14" East Precipitation Zone** This site was all-encompassing for the 10-14" precipitation zone in Wyoming following the removal of MLRA 46. Shifting lines to move only the frigid band of 10-14” precipitation to the foothills and creating a mesic 10-14” band will narrow the concept for 032XA150.
R032XY150WY	**Sandy (Sy) 5-9” Big Horn Basin Precipitation Zone,** The current description of the Sandy ecological site is a division of the original 32XY150 site. The separation was based on landforms, parent material, structure, and depth to gravel. Sandy soils without an argillic horizon, derived from sandstone, and with only minimal gravel are stable and produce more than other similar soils that were originally grouped in this site concept.

Table 1. Dominant plant species

Tree	Not specified
Shrub	(1) *Artemisia tridentata ssp. wyomingensis*

Herbaceous	(1) *Achnatherum hymenoides* (2) *Hesperostipa comata*

Legacy ID

R032XA150WY

Physiographic features

The Sandy ecological site generally occurs on slopes ranging from nearly level to moderately steep, up to 20 percent. Alluvial fans, stream terraces, and hillsides or ridges are the major landforms where this site exists. The site also occurs on relict stream terraces or fan remnants with minimal or no active soil deposition. Large, contiguous landforms within this landscape create a situation where one landform crosses climatic gradients. Variability in plant species can be observed across the climactic gradient.

The complexes of soil components mapped on these landforms are typically separated by depth to rock fragments in the soil profile or depth to bedrock (lithic or paralithic). Many of these landforms are erosional remnants and have soils ranging from shallow to very deep. The variability of soils across the landform is influenced by the geology's inherent chemistry . This will create pockets of calcareous or saline/sodic soils as well as areas that are not influenced by chemistry. Higher infiltration rates associated with the Sandy ecological site result in leaching of salts, carbonates, and other chemistry to a depth that no longer influences this plant community. Therefore, the Sandy ecological site is common on both non-calcareous and calcareous sandstone because of the leaching. Across the landform positions, soils will shift with the deposition of calcareous material or salt-laden materials or with the overflow of chemistry-laden runoff. With these transitions, the break between one ecological site and another (and the representative plant community for each) is often a broad and non-descript band between the two sites. This can make it difficult, when on the landscape, to identify clearly which site is dominant for a specific point along that transitional gradient.

There is no indication of a water table within 60 inches (150 cm) at any point throughout the calendar year. No additional overland flow of precipitation or moisture influences this site. This site also is characterized by no additional moisture capture. The Sandy ecological site may be identified in drainageways where downcutting or other hydrologic shifts has reduced or removed the additional runoff moisture to a point where the overflow plant community is not present (basin big sagebrush, basin wildrye, silver sagebrush). Production may be on the upper end of the range, but the plant composition more closely resembles the Sandy site.

Figure 2. Physiographic Image —Aerial View of landforms within LRU A.

Table 2. Representative physiographic features

Landforms	(1) Intermontane basin > Alluvial fan (2) Intermontane basin > Hillside (3) Intermontane basin > Stream terrace
Runoff class	Negligible to medium

Ponding frequency	None to rare
Elevation	3,700–6,000 ft
Slope	0–20%
Aspect	Aspect is not a significant factor

Climatic features

Annual precipitation and modeled relative effective annual precipitation ranges from 5 to 9 inches (127–229 mm). The normal precipitation pattern shows peaks in May and June and a secondary peak in September. The noted peaks account for approximately 50 percent of the mean annual precipitation. Much of the moisture that falls in the latter part of the summer time is lost by evaporation and much of the moisture that falls during the winter months is lost by sublimation.

Average snowfall in the Big Horn Basin Core is about 20 inches annually. Wide fluctuations may occur in yearly precipitation and result in more dry years than those with more than normal precipitation. Temperatures show a wide range between the summer and winter months and between daily maximums and minimums, due to the high elevation and dry air, which permits rapid incoming and outgoing radiation. Cold air outbreaks from Canada in winter move rapidly from northwest to southeast and account for extreme minimum temperatures. Chinook winds may occur in winter time and bring rapid rises in temperature. Extreme storms may occur during the winter months, but most severely affect ranch operations during the late winter and spring months. High winds generally are blocked from the basin by high mountains but can occur in conjunction with an occasional thunderstorm.

Growth of native cool-season plants begins approximately on April 1st and continues through to July 1st. Cool weather and moisture in September may produce some green-up of cool-season plants that will continue to late October. For detailed information visit the Natural Resources Conservation Service National Water and Climate Center at http://www.wcc.nrcs.usda.gov/. Basin, Emblem, Greybull, Lovell, Worland FAA AP and Worland are the representative weather stations for LRU A. The following graphs and charts are a collective sample representing the averaged normals and 30-year annual rainfall data for the selected weather stations from 1981 to 2010.

Table 3. Representative climatic features

Frost-free period (characteristic range)	106-116 days
Freeze-free period (characteristic range)	130-143 days
Precipitation total (characteristic range)	7-8 in
Frost-free period (actual range)	98-119 days
Freeze-free period (actual range)	128-149 days
Precipitation total (actual range)	6-8 in
Frost-free period (average)	111 days
Freeze-free period (average)	137 days
Precipitation total (average)	7 in

Climate stations used

- (1) EMBLEM [USC00483031], Burlington, WY
- (2) DEAVER [USC00482415], Deaver, WY
- (3) GREYBULL [USC00484080], Greybull, WY
- (4) BASIN [USC00480540], Basin, WY
- (5) LOVELL [USC00485770], Lovell, WY
- (6) GREYBULL S BIG HORN AP [USW00024048], Greybull, WY
- (7) WORLAND [USC00489770], Worland, WY
- (8) WORLAND [USW00024062], Worland, WY

Influencing water features

The characteristics of these upland soils have no influence from ground water (water table below 60 inches (150 cm)) and have minimal influence from surface water or overland flow. There may be isolated features that are affected by snowpack that persists longer than surrounding areas due to position on the landform (shaded or protected pockets). No streams are classified within this Sandy ecological site.

Soil features

The soils of this site are moderately deep to very deep (greater than 20 inches (51 cm) to bedrock), well to somewhat excessively well drained, and have moderate to rapid permeability. The soil characteristic with the most influence on the plant community is the permeability of the soil, which allows water to rapidly infiltrate into the soil profile and become available for plant use. The permeability also influences the soil chemistry by the leaching of salts, calcium carbonate, and other influencing chemical processes out of the zone of plant influence.

The general soil profile has a loamy fine sand or sandy loam surface. The subsurface consists of loamy sand to loam. These soils may have an alluvial layer (gravel or coarse sands) or interbedded sandstone and shale lower in the profile (below 20 inches (51 cm)). If the soil has an alluvial parent material, alluvial gravels can be present on the soil surface (20 percent or less) and throughout the soil profile of less than 35 percent by volume. For this ecological site, salts and calcium carbonate occur below the depth of plant influence (20 inches (51 cm)). If they are present in the upper 20 inches, they can be finely disseminated or as small masses or soft nodules in low concentrations throughout. Chemical characteristics for this site are listed below. Increases outside of the stated ranges of calcium carbonates or other soluble salts are potential transitions to a different ecological site.

Major soil series correlated to this site include Apron, Enos, Griffy, Neiber, Pavillion-like, Red Point, Saver, Sogzie-like, Trook, Wall, Wall-like, Wallson, Wallson-like, Willwood-like, Worland, and Worland-like. This list of soil series is subject to change upon completion and correlation of the initial soil surveys WY629, WY603, and WY617; as well as revisions to completed soil survey WY043.

Figure 9. Soils Profile Image.

Table 4. Representative soil features

Parent material	(1) Alluvium–interbedded sedimentary rock (2) Residuum–sandstone (3) Eolian deposits–metamorphic and sedimentary rock
Surface texture	(1) Gravelly sandy loam (2) Loamy sand (3) Loam (4) Fine sandy loam
Family particle size	(1) Coarse-loamy
Drainage class	Well drained to somewhat excessively drained

Permeability class	Moderate to rapid
Soil depth	20–60 in
Surface fragment cover <=3"	0–20%
Surface fragment cover >3"	0–5%
Available water capacity (0-40in)	1.2–6.3 in
Calcium carbonate equivalent (0-40in)	0–4%
Electrical conductivity (0-40in)	0–4 mmhos/cm
Sodium adsorption ratio (0-40in)	0–12
Soil reaction (1:1 water) (0-40in)	7.4–8.2
Subsurface fragment volume <=3" (Depth not specified)	0–34%
Subsurface fragment volume >3" (Depth not specified)	0–10%

Ecological dynamics

Mid-statured, cool-season perennial bunchgrasses are the dominant potential vegetation for this ecological site. Other significant vegetation includes Wyoming big sagebrush, winterfat, and a variety of forbs. The expected potential composition for this site is 70 percent grasses, 1 5 percent forbs, and 15 percent woody plants. Plant composition and production will vary naturally due to historic use and fluctuating precipitation.

Blue grama, prairie Junegrass, threeawn, and sand dropseed will increase as a community degrades (is disturbed). Degradation will cause the cool-season grasses such as needle and thread and Indian ricegrass to decrease in frequency and production. Continued pressure will allow plains pricklypear and weedy annuals to invade. Extended periods of drought and other climatic shifts have produced similar transitions in the vegetation.

Wyoming big sagebrush is limited in this system due to lack of moisture and lower water-holding capacity of the soils; this also relates to a lower risk of fire (lower fire frequency) due to reduced fine fuels and total woody canopy. Extended drought will cause stress and decadence or death in sagebrush quicker than in finer or heavier-textured soils because of the reduced water-holding capacity. In the absence of the natural disturbance regimes to encourage rejuvenation and cycling, sagebrush will begin to decrease in palatability and function, and increase in total canopy cover; however, the actual number of individual plants may not increase significantly but the overall size and coverage of each plant increases. It is interjected that changes in historic grazing use patterns have resulted in decadent or dying stands of sagebrush. The lack of and inconsistency of precipitation in this LRU limits the use of several brush management techniques. In isolated areas, mosaic or "patch" burns or mowing are utilized to rejuvenate aged stands of sagebrush, to create or enhance wildlife habitat, specifically for sage grouse and other sagebrush-obligate species.

Intensity and timing of precipitation limits the resilience of Wyoming big sagebrush in this system. Once sagebrush has been removed, especially where grasses have the resources to be competitive, seedling establishment is hindered by the competition for limited soil moisture. The loss of structure (height) for snow catch and woody canopy for moisture retention and protection from grazing and wind desiccation stresses young sagebrush seedlings quickly, reducing new establishment. Extended periods of time are required for natural reestablishment of sagebrush (beyond 25 years), limiting the function of natural recovery as a management tool.

Encroachment of blue grama occurs with a combination of disturbances (hoof action, defoliation, and compaction) as well as with the shift in climate (extended drought). The dense sod causes a shift in hydrology that creates a drier, harsher environment that continues to support the dense root system that can respond and capture moisture in the surface before it is lost. As these plants establish and continue to increase, they further alter the hydrologic

cycle by diverting more water off-site and increasing runoff with the dense, tight root system.

The ecological states and community phases as well as the dynamic processes driving the transitions between these communities have been determined by studying this ecological site under all management scenarios, including those that do not include cattle grazing. Trends in plant communities going from heavily grazed areas to lightly grazed areas, seasonal use pastures, and historical accounts have been used.

Studies support the need to revise the original Sandy ecological site to narrow the concept. The depth to a skeletal or gravel layer is considered to occur within this new concept only if it occurs below 20 inches (50 cm.) Soils with a sandy cap over a pronounced argillic horizon (bulge in clay) that then decrease in clay content are excluded. Also, soils must remain below 18 percent clay content throughout the top 20 inches (50 cm) of the soil profile. Current and historical site development data has noted a correlation with the amount of needle and thread and western wheatgrass with the fine-loamy and coarse-loamy particle-size classes. Finer-textured soils hold a higher ratio of western wheatgrass to needle and thread (or Indian ricegrass) and the opposite for coarser textured soils, which hold a higher ratio of needle and thread (or Indian ricegrass) to western wheatgrass. Soil p article-size classes are used to characterize the grain-size composition of the whole soil, including both the fine-earth fraction and the rock fragments in a soil based on percentage by weight. Coarse-loamy soils have 15 percent or more of fine sands or coarser and less than 18 percent clay; fine-loamy soils have 15 percent or more of fine sand or coarser with 18 percent or greater to less than 35 percent clays; and fine soils have more than 35 percent but less than 60 percent of clay.

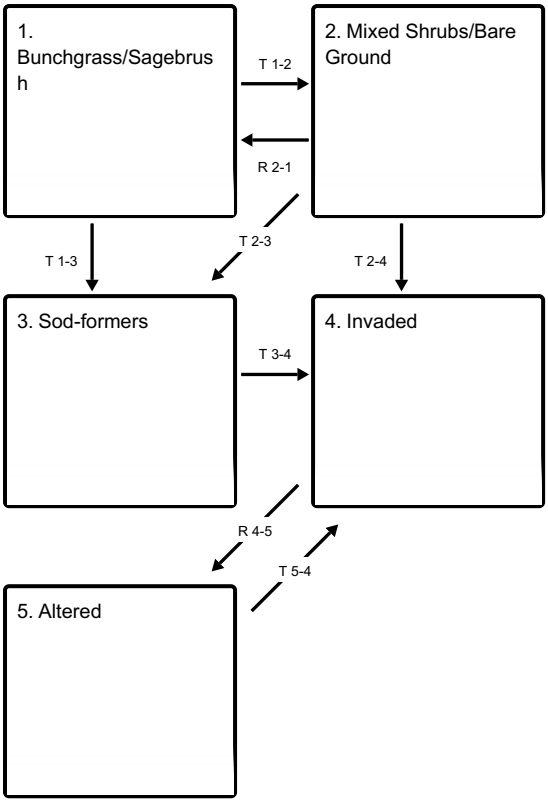
The narrowing of the site characteristics to less than 18 percent clay within the particle-size control section has eliminated the fine-loamy and fine particle-size classes from this concept. Communities will show variability to account for those soils that are on the margins of these breaks. The variability of the vegetative community is also related to the soil surface structure. Those soils with a platy structure appear to have slightly heavier textures with response to rain impact as well as vegetative responses. Management implications will be clarified, and the range of characteristics will be documented within the plant community tables.

The following State-and-Transition Model (STM) Diagram has five fundamental components: states, transitions, restoration pathways, community phases, and community pathways. The State, designated by the bold box, is a set of parameters with thresholds defined by ecological processes. A State can be a single community phase or suite of community phases. The Reference State is recognized as State 1. It describes the ecological potential and natural range of variability resulting from dynamic ecological processes that occur on the site. The designation of alternative States (State 2, etc.) in STMs denotes changes in ecosystem properties that cross a certain threshold.

Transitions are represented by the arrows between states moving from a higher state to a lower state (State 1 - State 2) and are denoted in the legend as a “T” (T1-2). They describe the variables or events that contribute directly to loss of state resilience and result in shifts between states. Restoration pathways are represented by the arrows between states returning from a lower state to a higher state (State 2 - State1 or better illustrated by State 1

State and transition model

Ecosystem states



T 1-2 - Frequent or high-intensity herbivory weakens the ability of the grasses to persist, especially during prolonged drought. Removal of or significant decrease in key grasses and a shift to a more pronounced sagebrush community renders a site difficult to restore back to the Reference State without mechanical or similar treatments.

T 1-3 - Long duration, high-intensity grazing reduces the bunchgrass component and encourages the mat- or sod-forming species. Prolonged drought stresses plants, opening the canopy for sod-formers. Removal of sagebrush by disturbances opens the canopy, aiding the transition.

R 2-1 - Removal or thinning of the sagebrush by mechanical or chemical means or by fire with remnant populations of native perennial desired grass species will lead to this community, if time is given for recovery and seedling establishment. Frequent use of this community during the dormant season will work to reduce the sagebrush through trampling and grazing but may encourage shorter-statured, more tolerant species and not the more desired species.

T 2-3 - Sod-forming species such as blue grama can tolerate high levels of use and will maintain as other native species decline. This decline creates a sagebrush–sod-former community that is resistant to change with management. Impacts to sagebrush by disease or insect damage will shift this to the secondary community phase.

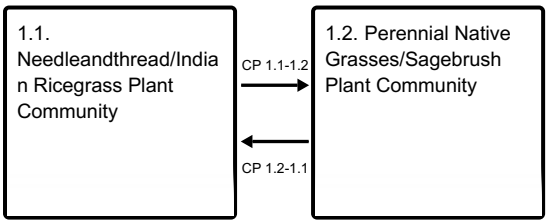
T 2-4 - When seed sources are prevalent for invasive species, stress from drought, wildfire, or other natural and man disturbances, removes or exposes the soil and presents a niche for invasion by undesirable weeds.

T 3-4 - The interstitial spaces within the patchy canopy of sod-formers leaves areas for weedy species to establish, especially with disturbance or high traffic areas.

R 4-5 - Integrated pest management plan and intense weed control after and possibly before seedbed preparation will be necessary to overcome a severe weed infestation. Working a location and using either improved varieties, native seed, or, in some cases, an introduced species suited for the management use intended may be the only way to overcome some invasive species.

T 5-4 - In the reclamation or restoration process, or after a land disturbance occurs, if no management is put into place to prevent a reoccurrence or a new infestation of weeds, the community will revert or transition to an invaded state. Wildfire, prescribed burning, drought, or frequent and severe misuse by large herbivores can be a source of the disturbance that either opens the canopy or introduces the species to the location.

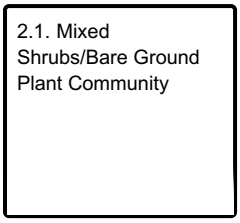
State 1 submodel, plant communities



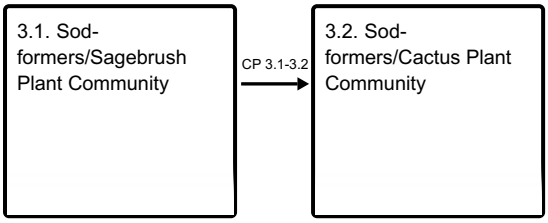
CP 1.1-1.2 - Historic use patterns, drought, and climatic shifts have attributed to the decline in needle and thread and Indian ricegrass. As bare ground increases, species such as prairie Junegrass, blue grama, and threadleaf sedge increased as along with the canopy of sagebrush.

CP 1.2-1.1 - Removal of the historic use patterns in favor of a rest rotation system and the implementation of wildlife management programs has helped to reduce the grazing pressure and allow rest for recovery. This also allows grasses the opportunity to increase within the interspaces.

State 2 submodel, plant communities

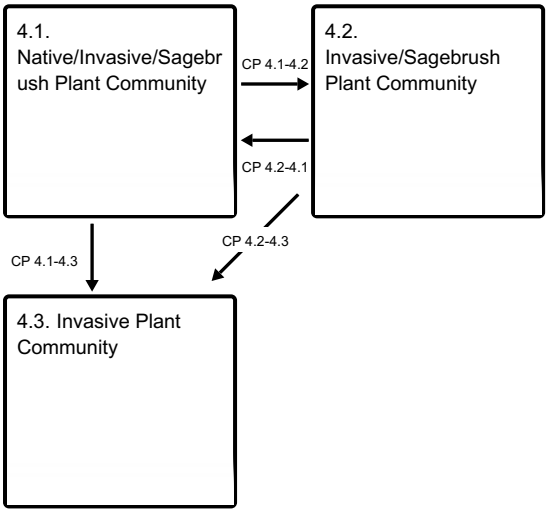


State 3 submodel, plant communities



CP 3.1-3.2 - As the mat-forming species increase with continued stress or pressure, hydrology is altered, and sagebrush begins to decrease and will eventually be removed. Cactus increases in this transition due to the open interspaces between patches of sod-formers.

State 4 submodel, plant communities



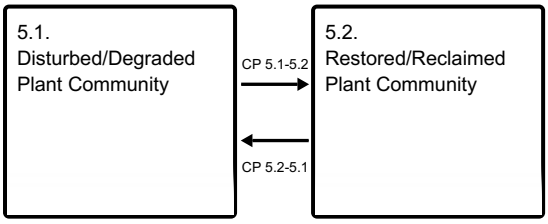
CP 4.1-4.2 - The competition for limited resources with drought stress or grazing pressure will allow invasive species to become dominant, leaving only remnant populations of natives. Non-use allows soils to become vulnerable to invasive species in these stressed conditions, thus allowing their expansion.

CP 4.1-4.3 - A major disturbance that removes sagebrush as well as other native herbaceous species leaves the community vulnerable to invasive species.

CP 4.2-4.1 - The integration of a pest management/weed control plan in conjunction with intensive grazing management over time will encourage the remnant populations of natives to expand. Eradication of invasive species may not be possible, but it is possible to encourage natives to persist.

CP 4.2-4.3 - Loss of sagebrush by major disturbance (fire, mechanical alteration, chemical means) will encourage the invasive species to become a near-monoculture population.

State 5 submodel, plant communities



CP 5.1-5.2 - Reclamation or restoration with reseeding, integrated pest management, and long-term prescribed grazing or other managed use of a landscape is needed to shift a disturbed community back to a representative or functional plant community.

CP 5.2-5.1 - If a reclaimed or restored site is not managed for the species implemented, (non-use or overuse), the community will revert back or fail to establish and will remain in a degraded community phase.

State 1
Bunchgrass/Sagebrush

The Reference State, State 1, is labeled as the Bunchgrass/Sagebrush State. Wyoming big sagebrush has a foothold in the community but mid-stature bunchgrasses are the dominant contributors to composition.

Characteristics and indicators. This State is characterized by the key species, including 10 percent or less composition by cover of Wyoming big sagebrush, with predominantly needle and thread and Indian ricegrass (30-50 percent composition). Areas of thickspike wheatgrass exist with the other minor components to the overall composition which are prairie Junegrass, bottlebrush squirreltail, sand dropseed, threeawn, blue grama, and threadleaf sedge.

Dominant plant species

- Wyoming big sagebrush (*Artemisia tridentata ssp. wyomingensis*), shrub
- Indian ricegrass (*Achnatherum hymenoides*), grass
- needle and thread (*Hesperostipa comata*), grass

Community 1.1
Needleandthread/Indian Ricegrass Plant Community

Figure 10. Community 1.1 – Reference Site located east central Park county, with needleandthread and Indian Ricegrass.

Community Phase 1.1 is the Reference Plant Community; however, it is declining in occurrence on the landscape. There are several potential factors that are causing this decline, however the change in timing of precipitation and temperatures (spring warmup/fall freeze) or lack of precipitation could be the dominant driving factors for this loss. State 1, including Community Phase 1.1, evolved with grazing by large herbivores. The potential vegetation consists of 70 percent grasses or grass-likes, 20 percent forbs, and 10 percent woody plants. This plant community is found on properly managed landscapes that include grazing or ecosystem-based management tools, with natural disturbance regimes and on areas that receive occasional short periods of rest. Changes in herbivory pressure by sheep and wildlife in the area have allowed Wyoming big sagebrush to become increasingly woody and decadent. This lent to the perception of increased woody canopy; however, the community is still dominated by cool-season perennial grasses. Overall, a stronger presence of short, warm-season grasses (blue grama) has increased across the entire basin, but has remained as a secondary component in this Reference Community. Historically, the Reference State evolved under a low fire frequency, estimated to be 195 to 235 years between burns on the same community patch, and sagebrush has a post-fire recovery timeframe of 50-120 years or more in arid systems (Baker, 2006) and with grazing pressure by large ungulates (elk, bison, deer, or antelope). Needle and thread, Indian ricegrass, and thickspike wheatgrass are the dominant grasses. Other grasses that are common include prairie Junegrass, Sandberg bluegrass, blue grama, threadleaf sedge, and threeawn. Forbs common to this site

include fleabanes, fringed sagewort, wild parsley, lemon scurfpea, and scarlet gaura. Wyoming big sagebrush and winterfat are conspicuous components of the community and can make up to 10 percent of the foliar cover. The overstory of sagebrush and understory of grass and forbs provide a diverse plant community overall. The total annual production (air-dry weight) of this community phase is about 400 pounds per acre, but it can range from about 225 lbs./acre in unfavorable years to about 600 lbs./acre in above average years.

Resilience management. Rangeland Health Implications/Indicators: Diversity of the plant species found on this site allows for a high tolerance to drought, allowing persistence in the limiting climatic conditions of the Big Horn Basin. Wyoming big sagebrush in conjunction with the mid-bunchgrasses (needle and thread and Indian ricegrass), rhizomatous species (western wheatgrass and thickspike wheatgrass), and the short-statured bunchgrasses (prairie Junegrass, Sandberg bluegrass, and threeawn) help to provide snow catch, holding moisture to maximize availability during the growing season. The adaptive species in this community respond to timing of precipitation, varying in composition but maintaining cover through a variety of conditions. As an example of this adaptability, needle and thread is dependent upon early spring moisture to perform well. Years with late spring/early summer moisture will produce minimal to no needle and thread but will have an excellent cover of prairie Junegrass. However, a year with late fall moisture and a slow warm up with spring moisture will produce an excellent cover of Sandberg bluegrass but minimal production for prairie Junegrass and needle and thread. The persistence and adaptability from year to year of these species allows for quick recovery once normal precipitation returns. This adaptability or variability in composition is one factor for the natural shift between Phases 1 and 2. Extended periods of drought, changes in land usage, and other natural and human-derived impacts assist with this shift, but the community is not at risk of transitioning into a different state unless a catastrophic impact occurs. This community, as the Reference, is indicative of rangeland health which is based on site and soil stability, watershed function, and biologic integrity.

Dominant plant species

- Wyoming big sagebrush (*Artemisia tridentata ssp. wyomingensis*), shrub
- Indian ricegrass (*Achnatherum hymenoides*), grass
- needle and thread (*Hesperostipa comata*), grass

Table 5. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	200	310	420
Shrub/Vine	20	50	100
Forb	5	40	80
Total	**225**	**400**	**600**

Table 6. Ground cover

Tree foliar cover	0%
Shrub/vine/liana foliar cover	0-10%
Grass/grasslike foliar cover	30-60%
Forb foliar cover	0-5%
Non-vascular plants	0%
Biological crusts	0-5%
Litter	5-15%
Surface fragments >0.25" and <=3"	0-20%
Surface fragments >3"	0-5%
Bedrock	0%
Water	0%
Bare ground	20-35%

Table 7. Soil surface cover

Tree basal cover	0%
Shrub/vine/liana basal cover	0%
Grass/grasslike basal cover	0%
Forb basal cover	0%
Non-vascular plants	0%
Biological crusts	0-5%
Litter	5-15%
Surface fragments >0.25" and <=3"	0-20%
Surface fragments >3"	0-5%
Bedrock	0%
Water	0%
Bare ground	20-35%

Table 8. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	–	0-2%	1-5%	1-5%
>0.5 <= 1	–	1-10%	1-25%	1-5%
>1 <= 2	–	0-5%	0-10%	0-2%
>2 <= 4.5	–	–	–	–
>4.5 <= 13	–	–	–	–
>13 <= 40	–	–	–	–
>40 <= 80	–	–	–	–
>80 <= 120	–	–	–	–
>120	–	–	–	–

Figure 12. Plant community growth curve (percent production by month). WY0501, 5-9BH Upland sites. Monthly percentages of total annual growth for all upland sites with dominantly C3 Cool season plants..

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
			15	50	20	5		10			

Community 1.2
Perennial Native Grasses/Sagebrush Plant Community

Figure 13. Reference Community 1.2 - Sandy 5-9" Mesic site within Big Horn Basin.

The secondary phase of the Reference Community (1.2), is captured as the At-Risk Community. Although it is similar with only minor shifts in composition and function, the loss of Indian ricegrass and the increase in woody cover leaves this site at risk of further degradation with continued stress or pressure by herbivory. The community can be found on areas that are within the scope of historic disturbances such as herbivory by large ungulates and sporadic wildfires. Properly managed locations with grazing with periodic short intervals of rest support this plant community and production potential. The vegetation composition is 65 percent grasses or grass-like plants, 10 percent forbs, and 25 percent woody plants. The Reference State is dominated by cool-season mid-statured grasses. The major understory of grasses and grass-like plants includes needle and thread, rhizomatous wheatgrasses, blue grama, threadleaf sedge, prairie Junegrass, and Sandberg bluegrass. The variety of forbs and half-shrubs commonly found include scarlet globemallow, fringed sagewort, lemon scurfpea, sulfur buckwheat, hairy false goldenaster, and spiny phlox. Wyoming big sagebrush can make up 25 percent of the annual production. The overstory of Wyoming big sagebrush and understory of grasses and forbs maintain the diverse structure of the plant community. Blue grama has increased within this community, as has Wyoming big sagebrush, and yucca when present; however, they are not the most prevalent species. The shift in species has an impact on moving or changing the hydrology of the site. Plains pricklypear cactus will also have increased but occurs only in small patches. Indian ricegrass has decreased and may occur in only trace amounts under the sagebrush canopy or within the patches of pricklypear; whereas needle and thread and winterfat have maintained and are a common component in this community. The total annual production (air-dry weight) of this community is about 350 pounds per acre, but it can range from about 190 lbs./acre in unfavorable years to about 580 lbs./acre in above average years.

Resilience management. Rangeland Health Implications/Indicators: This plant community is resistant to change. The herbaceous cover is intact, and plant vigor and replacement capabilities are enough to maintain during periods of moderate grazing pressure with recovery periods; however, species composition can be altered through long-term overgrazing or increased intensity of defoliation. The overall canopy is adequate, but the shift in structure of cover and increase in bare ground opens a niche for weedy species and may intensify the droughty nature of the soils with increased water demands by the woody species as well as shallower-rooted annuals. Bare ground averages 30 to 45 percent, woody coverage has increased (due to reduced herbaceous cover, to an average of 20 to 35 percent cover. Litter overall appears to be similar across this state (State 1); similarly, the biological crust cover does not vary. Water flow patterns and litter movement may be occurring but only on steeper slopes. Incidence of pedestalling is minimal, and soils mostly are stable with only minimum evidence of soil loss. The watershed is functioning, and the biotic community is intact.

Dominant plant species

- Wyoming big sagebrush (*Artemisia tridentata ssp. wyomingensis*), shrub
- needle and thread (*Hesperostipa comata*), grass
- thickspike wheatgrass (*Elymus lanceolatus ssp. lanceolatus*), grass
- prairie Junegrass (*Koeleria macrantha*), grass

Table 9. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	160	240	375
Shrub/Vine	25	75	125
Forb	5	35	80
Total	**190**	**350**	**580**

Table 10. Ground cover

Tree foliar cover	0%
Shrub/vine/liana foliar cover	10-30%
Grass/grasslike foliar cover	20-50%
Forb foliar cover	2-10%
Non-vascular plants	0%
Biological crusts	0-2%
Litter	5-15%
Surface fragments >0.25" and <=3"	0-20%
Surface fragments >3"	0-5%
Bedrock	0%
Water	0%
Bare ground	25-40%

Table 11. Soil surface cover

Tree basal cover	0%
Shrub/vine/liana basal cover	0%
Grass/grasslike basal cover	0%
Forb basal cover	0%
Non-vascular plants	0%
Biological crusts	0-2%
Litter	5-15%
Surface fragments >0.25" and <=3"	0-20%
Surface fragments >3"	0-5%
Bedrock	0%
Water	0%
Bare ground	25-40%

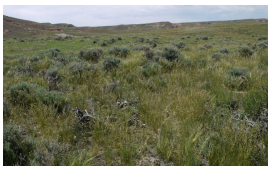
Table 12. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	–	0-2%	1-5%	5-10%
>0.5 <= 1	–	5-25%	5-25%	1-5%
>1 <= 2	–	0-5%	0-5%	0-2%
>2 <= 4.5	–	–	–	–
>4.5 <= 13	–	–	–	–
>13 <= 40	–	–	–	–
>40 <= 80	–	–	–	–
>80 <= 120	–	–	–	–
>120	–	–	–	–

Figure 15. Plant community growth curve (percent production by month). WY0501, 5-9BH Upland sites. Monthly percentages of total annual growth for all upland sites with dominantly C3 Cool season plants..

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
			15	50	20	5		10			

Pathway CP 1.1-1.2
Community 1.1 to 1.2



Needleandthread/Indian Ricegrass Plant Community

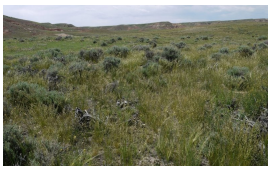
Perennial Native Grasses/Sagebrush Plant Community

Timing of grazing, drought, and climatic shifts—The Big Horn Basin is known for the significant populations of sheep and the seasonal move to the mountains for summer grazing and back to the basin for winter grazing. Historically, this site was used during the late fall and winter before livestock could be moved on federal summer allotments. The repetitive use of sensitive species will slowly remove them from the system. This impact is one factor that has reduced Indian ricegrass and encouraged Sandberg bluegrass and prairie Junegrass in some areas. Long periods of drought and shifts in spring precipitation patterns have weakened and impacted the productivity and vigor of most species, leaving a drier climate for sensitive species to establish. Although the species of herbivory and timing has changed with the installation of more grazing management, drought and other climatic patterns still pose a continual threat to the integrity of the plant communities.

Context dependence. Shifts in climate may be a major driver for this transition and may be the restriction to recovery in some instances.

Pathway CP 1.2-1.1
Community 1.2 to 1.1

Perennial Native Grasses/Sagebrush Plant Community



Needleandthread/Indian Ricegrass Plant Community

Long-term prescribed grazing, brush management—Integration of a rotational grazing system and brush management, the native bunchgrasses will begin to reestablish in this community. Recovery may take an extended

period, estimated at 5 to 10 years before significant change is noticed. Prescribed grazing, especially following sagebrush canopy treatments helps to remove woody debris and exposes a seedbank to encourage the native species. Allowing rest during critical seedling establishment and reducing competition for resources aids the recovery of native species. Hoof action helps to break up duff layers and open the seedbed to allow the desired bunchgrasses (needle and thread, Indian ricegrass) and rhizomatous wheatgrasses, with prairie Junegrass to reestablish or to increase, which drives the recovery to the Reference Community (1.1). This hoof action, along with brush treatment, can be a tool to break up mat-forming species, which addresses the shifting hydrologic cycle and holds the water on-site rather than allowing it to be lost off-site. A long-term management strategy may be required before any trend toward Reference is noticed. The overstory of Wyoming big sagebrush may be the one factor that could require further manipulation to reduce canopy and composition to the 10 percent that is desired.

Conservation practices

Integrated Pest Management (IPM)
Upland Wildlife Habitat Management
Prescribed Grazing
Grazing Management Plan

State 2
Mixed Shrubs/Bare Ground

Persistence of drought or frequent overuse by livestock or wildlife leads to a decline of the herbaceous species, creating the Mixed Shrub and *Bare Ground* State. This State can be exacerbated by insects and other human disturbances. The total woody canopy cover does not necessarily always increase with this community, but the percentage of composition by cover and production is swayed by the decrease of herbaceous vegetation and the relative stability of woody production, creating the appearance of increased canopy by shrubs.

Characteristics and indicators. The coarse texture of the soils on this site provides the opportunistic shrubs such as shadscale, spiny hopsage, yucca, skunkbush sumac, and four-wing saltbush to establish along with Wyoming big sagebrush. These shrubs provide protection and create a niche for most herbaceous understory to persist and maintain some vigor in difficult conditions. The additional moisture provided by the shade of the canopy as well as protection from grazing benefit most native grasses.

Resilience management. As the herbaceous cover declines and the site continues to weaken, the sagebrush and other shrub cover is susceptible to attack by insects, disease, and general old age that can remove it from the system leaving it at-risk of invasion or transition to a more degraded state. There is a high level of variability of species in this State (State 2, Mixed Shrubs/*Bare Ground*), that will shift with precipitation patterns or as a response to past management. Only one well-defined community will be provided, with discussion of transitions or variances from this community. The overall droughty nature of coarse textured soils exacerbates the impact of droughty conditions and reduces the resilience and resistance of this site to further shift during extended dry periods. The presence of spiny hopsage and yucca on this site is not frequent, but when it does occur it can easily become prominent, specifically for winter grazing allotments. Yucca's growth habits produce a more pronounced pedestalling and drift or scour pattern on the landscape than seen with sagebrush. Risk of wildfire within this state is minimal due to the lack of fine fuels within the understory, but the canopy of the woody vegetation can easily carry a fire under certain weather conditions. The loose or coarser texture of these soils allows for increased wind scour and drifting or mounding to occur with more open ground between canopy "patches" that further hinders fire movement. Depending upon the prescription of use, trailing and other erosional patterns are highly visible in this State.

Dominant plant species

- Wyoming big sagebrush (*Artemisia tridentata ssp. wyomingensis*), shrub
- fourwing saltbush (*Atriplex canescens*), shrub
- spiny hopsage (*Grayia spinosa*), shrub
- needle and thread (*Hesperostipa comata*), grass
- thickspike wheatgrass (*Elymus lanceolatus ssp. lanceolatus*), grass
- prairie Junegrass (*Koeleria macrantha*), grass

Community 2.1
Mixed Shrubs/Bare Ground Plant Community

Figure 16. Sagebrush Dominated Community with minimal coverage in woody canopy gaps.

This plant community is the result of frequent and severe grazing and/or protection from fire. Wyoming big sagebrush dominates this plant community, as the annual production of sagebrush exceeds 25 percent. Wyoming big sagebrush is a significant component of the plant community and the desirable mid-statured cool-season grasses have been greatly reduced. In response to the coarser textured soils, Yucca can be a major component of this community. The dominant grasses are needle and thread, Sandberg bluegrass, prairie Junegrass, and blue grama with dispersed areas of threadleaf sedge. Patches of pricklypear cactus are more noticeable on the landscape, and the amount of bare ground is more prevalent. As compared with the Reference Plant Community 1.1, the annual production is slightly lower. Woody production and cactus maintain production even though herbaceous production has declined. This community is vulnerable to invasive weeds such as cheatgrass, Russian knapweed, or leafy spurge if a seed source is available, leaving it labeled as at-risk of further degradation. The total annual production (air-dry weight) of this state averages 385 pounds per acre, but it can range from 205 lbs./acre in unfavorable years to 560 lbs./acre in above average years.

Resilience management. Rangeland Health Implications/Indicators: This plant community is resistant to change as the stand becomes more decadent. The increased interspaces make this community susceptible to invasive species. Continued frequent and severe grazing or the removal of grazing does not seem to affect the composition or structure of the plant community. Plant diversity is moderate to poor, vigor is diminished, and replacement capabilities are limited due to the reduced number of mid-statured cool-season grasses. Plant litter is noticeably less when compared to the Reference Plant Community. Soil erosion is accelerated because of increased bare ground. Water flow patterns and pedestalling are obvious. Infiltration is reduced, and runoff is increased. Rill channels may be noticeable in the interspaces and gullies may be establishing where rills have concentrated down slope.

Dominant plant species

- Wyoming big sagebrush (*Artemisia tridentata ssp. wyomingensis*), shrub

Table 13. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	150	200	250
Shrub/Vine	50	150	250
Forb	5	35	60
Total	**205**	**385**	**560**

Table 14. Ground cover

Tree foliar cover	0%

Shrub/vine/liana foliar cover	10-35%
Grass/grasslike foliar cover	5-20%
Forb foliar cover	0-5%
Non-vascular plants	0%
Biological crusts	0-1%
Litter	5-10%
Surface fragments >0.25" and <=3"	0-20%
Surface fragments >3"	0-5%
Bedrock	0%
Water	0%
Bare ground	35-50%

Table 15. Soil surface cover

Tree basal cover	0%
Shrub/vine/liana basal cover	0%
Grass/grasslike basal cover	0%
Forb basal cover	0%
Non-vascular plants	0%
Biological crusts	0-1%
Litter	5-10%
Surface fragments >0.25" and <=3"	0-20%
Surface fragments >3"	0-5%
Bedrock	0%
Water	0%
Bare ground	35-50%

Table 16. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	–	0-2%	1-5%	1-5%
>0.5 <= 1	–	5-30%	5-20%	1-5%
>1 <= 2	–	0-5%	0-5%	0-2%
>2 <= 4.5	–	–	–	–
>4.5 <= 13	–	–	–	–
>13 <= 40	–	–	–	–
>40 <= 80	–	–	–	–
>80 <= 120	–	–	–	–
>120	–	–	–	–

Figure 18. Plant community growth curve (percent production by month). WY0501, 5-9BH Upland sites. Monthly percentages of total annual growth for all upland sites with dominantly C3 Cool season plants..

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
			15	50	20	5		10			

State 3
Sod-formers

The dominant sod-forming grass or grass-like that currently exists within this LRU is blue grama; however, there is a limited component of threadleaf sedge. Both are species that persist as a component of the perennial vegetation naturally (in Reference communities) within this ecological site. The general tendency is for these species to increase with prolonged drought or under grazing pressure, becoming dominant.

Characteristics and indicators. This community is characterized by a dominance of blue grama with some threadleaf sedge. Remnants of the other vegetation natural to this site will persist, but is restricted by the dense mats of blue grama.

Resilience management. Together as the dominant species, they alter the hydrology of the site by increasing the surface runoff from the dense shallow root system that inhibits the movement of water through or will direct surface flow around the edge of the “clump,” concentrating flow into channel-like patterns, creating a drier environment for native grass species and forbs to persist.

Dominant plant species

- Wyoming big sagebrush (*Artemisia tridentata ssp. wyomingensis*), shrub
- blue grama (*Bouteloua gracilis*), grass
- threadleaf sedge (*Carex filifolia*), grass

Community 3.1
Sod-formers/Sagebrush Plant Community

Figure 19. Blue grama dominated community with sagebrush still present.

This plant community is the result of continuous season-long grazing, recurrent over utilization, or prolonged drought, which has adversely affected the perennial grasses and shrub component, in turn encouraging the low-statured, mat-forming (tillering) grasses to expand. The effect of blue grama and threadleaf sedge with their short, dense root structure, is a decrease of water infiltration which increases channelization of runoff between vegetation patches. Decreased infiltration coupled with the lack of structure to hold moisture and compounded by drought will reduce the shrub component further. Dense, interspersed patches of blue grama and threadleaf sedge sod are the major components of this community. Incidental occurrences of other perennial natives occur within the sagebrush canopy or the protective ring of the pricklypear cactus clumps. Overall, Wyoming big sagebrush has been reduced in vigor and abundance across this community phase, but it persists on the landscape (average of 5-10 percent canopy cover). When compared to the Reference Plant Communities 1.1 and 1.2, blue grama has increased significantly, making up 30 to 60 percent of the canopy. Pricklypear cactus is prevalent on the site, and other cool-season mid-statured grasses, perennial forbs, and most shrubs have been greatly reduced. Production has significantly decreased, and bare ground may not vary or will increase (longer extents of bare ground between densely vegetated areas). The total annual production (air-dry weight) of this community phase is about 150 pounds per acre, but it can range from about 60 lbs./acre in unfavorable years to about 300 lbs./acre in above average years. The higher productivity generally is in response to Wyoming big sagebrush production on the site. Rubber rabbitbrush and other woody species are present as well (5-10 percent), influencing overall production.

Resilience management. Rangeland Health Implications/Indicators: This community is at-risk of transitioning to a sod-bound community with no woody vegetation. The short-statured tillering plants are resistant to change. No added effect to the plant composition or structure is apparent with continued overuse or with the application of non-use. The shrub component will degrade and eventually will be removed from the plant community under either scenario. The biotic integrity of this community phase is not functional and plant diversity is extremely low. The plant vigor is weakened, and replacement capabilities are limited due to the reduced number of mid-statured cool-season bunchgrasses. This sod-bound plant community is resistant to water infiltration. While the sod protects the rooted area, edge areas are affected by excessive runoff that can cause rills and gully erosion. Water flow patterns are obvious in areas of bare ground, and pedestalling is prominent along the sod edges. Rill channels are noticeable in the interspaces and down slope. The watershed may or may not be functioning, as runoff may affect adjoining sites. This community can improve with intensive management requiring mechanical manipulation. However, once the sagebrush component has been lost, recovery or transition is not as feasible. The potential to recover compared to the potential to shift into Community Phase 3.2 (stable and most degraded) creates the at-risk label. Drought stress will create a die off or die-back of both blue grama and threadleaf sedge. During extended periods of drought, large areas of die-back leaves the area sensitive to hoof action. When the blue grama plant dies, it tends to die from the center out, but will remain intact until disturbed (trampling, vehicle traffic, ground disturbances). Once disturbed, the plants quickly degrade, leaving the surface vulnerable to erosion.

Dominant plant species

- Wyoming big sagebrush (*Artemisia tridentata ssp. wyomingensis*), shrub
- blue grama (*Bouteloua gracilis*), grass

Table 17. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	50	100	200
Shrub/Vine	20	45	75
Forb	0	5	25
Total	**70**	**150**	**300**

Table 18. Ground cover

Tree foliar cover	0%
Shrub/vine/liana foliar cover	5-10%
Grass/grasslike foliar cover	30-50%
Forb foliar cover	0-5%
Non-vascular plants	0%
Biological crusts	0-1%
Litter	0-5%
Surface fragments >0.25" and <=3"	0-20%
Surface fragments >3"	0-5%
Bedrock	0%
Water	0%
Bare ground	35-50%

Table 19. Soil surface cover

Tree basal cover	0%
Shrub/vine/liana basal cover	0%
Grass/grasslike basal cover	0%

Forb basal cover	0%
Non-vascular plants	0%
Biological crusts	0-1%
Litter	0-5%
Surface fragments >0.25" and <=3"	0-20%
Surface fragments >3"	0-5%
Bedrock	0%
Water	0%
Bare ground	35-50%

Table 20. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	–	0-2%	5-40%	1-5%
>0.5 <= 1	–	5-10%	5-20%	1-5%
>1 <= 2	–	0-5%	0-5%	0-2%
>2 <= 4.5	–	–	–	–
>4.5 <= 13	–	–	–	–
>13 <= 40	–	–	–	–
>40 <= 80	–	–	–	–
>80 <= 120	–	–	–	–
>120	–	–	–	–

Figure 21. Plant community growth curve (percent production by month). WY0504, 5-9 BH Upland Sites Warm Season Dominate. Monthly percentages of total annual growth based on a predominately C4 warm season plant community with shrubs and some C3 plants. Generally sod-forming community..

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	15	25	45	10	0	5	0	0	0

Community 3.2
Sod-formers/Cactus Plant Community

Figure 22. Blue grama Community with Cactus in a good year for Sandberg bluegrass.

Further degradation of the Sod/Sagebrush Community Phase (3.1) to the Sod/Cactus Community Phase (3.2) occurs relatively easily under long-term drought or continued pressure on the remaining shrubs. This phase transition could be viewed as successional phases. A dense sod of blue grama with threadleaf sedge intermixed, is dominant with increasing pricklypear cactus in the community. Cactus density has the potential to increase to a level that inhibits the ability for livestock to move through or graze the available forage. Wyoming big sagebrush has been generally removed from the community with only isolated occurrences. Rubber rabbitbrush is significantly reduced but may persist on the landscape. The dense mats of roots of blue grama and threadleaf sedge and the aggressive stolon of plains pricklypear cactus can tolerate high levels of use and will persist as other native species are removed from the community, including Wyoming big sagebrush. This decline creates a Sod/Cactus Community that is resistant to change with management. When compared to the Reference State (1.1 and 1.2), blue grama and plains pricklypear cactus have increased. All cool-season mid-statured grasses, forbs, and most shrubs have been greatly reduced or removed. The dense and frequent clumps of cactus do offer a niche for some native cool-season grasses to persist in the community but suppressed in expression. Production is greatly reduced from Reference, but minimal difference in production is seen between phase 3.1 and 3.2. The ability of low-statured sod-formers to respond to the amount and timing of precipitation is not as significant as other mid-statured cool-season grasses, such as needle and thread and Sandberg bluegrass; however, marked swing in average production between wet and dry years is seen. The production of substantial inflorescence and culm growth is a more prominent response for these short-statured grasses. Production is provided as an average or mean number and is not intended to cover the full range of production potential for this community. Total average annual production is 175 pounds per acre, but it can range from 75 lbs./acre in unfavorable years to 325 lbs./acre in above average years.

Resilience management. Rangeland Health Implications/Indicators: This community is extremely resistant to change and continued frequent and severe grazing or the removal of grazing does not seem to affect the plant composition or structure of the plant community. The biotic integrity of the Sod-Formers State is not functional, plant diversity is extremely low, and vigor is significantly weakened, and replacement capabilities are limited due to the reduced number of cool-season grasses. The dense root mat of this community is resistant to water infiltration, and off-site areas are affected by excessive runoff that can cause rills and gully erosion. Water flow patterns are obvious in the bare ground areas and pedestalling is apparent along the sod edges. Rill channels are noticeable in the interspaces and downslope. The watershed may or may not be functioning, as runoff may affect adjoining sites. The added competition and rooting nature of cactus allows it to become significant or dominant on the site. Although not documented in this LRU at this time, it has been noted in other areas of Wyoming, that pricklypear cactus can form in dense patches that inhibit animal movement through the area, preventing the use for grazing and hindering wildlife movement and use as well.

Dominant plant species

- blue grama (*Bouteloua gracilis*), grass

Table 21. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	50	110	200
Forb	25	55	100
Shrub/Vine	0	10	25
Total	**75**	**175**	**325**

Table 22. Ground cover

Tree foliar cover	0%
Shrub/vine/liana foliar cover	0-5%
Grass/grasslike foliar cover	30-50%
Forb foliar cover	0-15%
Non-vascular plants	0%
Biological crusts	0-1%

Litter	0-5%
Surface fragments >0.25" and <=3"	0-20%
Surface fragments >3"	0-50%
Bedrock	0%
Water	0%
Bare ground	35-50%

Table 23. Soil surface cover

Tree basal cover	0%
Shrub/vine/liana basal cover	0%
Grass/grasslike basal cover	0%
Forb basal cover	0%
Non-vascular plants	0%
Biological crusts	0-1%
Litter	0-5%
Surface fragments >0.25" and <=3"	0-20%
Surface fragments >3"	0-5%
Bedrock	0%
Water	0%
Bare ground	35-50%

Table 24. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	–	0-1%	5-40%	1-15%
>0.5 <= 1	–	1-5%	5-20%	1-5%
>1 <= 2	–	0-1%	0-5%	0-2%
>2 <= 4.5	–	–	–	–
>4.5 <= 13	–	–	–	–
>13 <= 40	–	–	–	–
>40 <= 80	–	–	–	–
>80 <= 120	–	–	–	–
>120	–	–	–	–

Figure 24. Plant community growth curve (percent production by month). WY0504, 5-9 BH Upland Sites Warm Season Dominate. Monthly percentages of total annual growth based on a predominately C4 warm season plant community with shrubs and some C3 plants. Generally sod-forming community..

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	15	25	45	10	0	5	0	0	0

Pathway CP 3.1-3.2
Community 3.1 to 3.2

Sod-formers/Sagebrush Plant Community

Sod-formers/Cactus Plant Community

Intensive brush management, frequent or severe grazing, and drought—The altered hydrology of this community has created a drier soil environment and reduced seedling establishment of native grasses and shrubs. Once sagebrush is removed from this community by intense grazing pressure, drought and insect damage, or by wild or prescribed fire, the community will phase into a Sod/Cactus Community. The Wyoming big sagebrush component of this community is the at-risk species and is replaced in dominance by pricklypear cactus. Drought alone, or with continuous grazing pressure, will create a sagebrush canopy that is decadent and dying. The sod-dominated community reduces the ability for sagebrush to propagate, also leading to a recession of sagebrush. The influences of fire are rare and generally have little influence on this community due to the lack of fine fuels and canopy cover to carry it; but in rare circumstances, isolated areas may burn within the shrub canopy. In some cases, rubber rabbitbrush will persist or increase slightly on a site as sagebrush diminishes. It is also noted that with periods of drought there is a noted decrease in the health and vigor of threadleaf sedge and blue grama. The dense root structure of the sod-former is reduced and easily disturbed with hoof action.

State 4
Invaded

Wyoming rangelands, much like the neighboring states, has quickly fallen victim to the aggressive invasion of cheatgrass, also called downy brome (*Bromus tectorum*). The rapid development of an extensive seedbank and duff layer forms with the potential for multiple growth cycles throughout a year. The advantageous ability of cheatgrass to persist through the winter under a blanket of snow and sprout early makes it difficult for natives to outcompete it for limited resources. Shifts in climatic patterns, changes in management, and exposure to human activity are a few of the explanations for the current flush and rapid expansion across the western United States. Although cheatgrass is the most prevalent large-scale threat for rangeland managers, a variety of knapweeds (spotted, Russian, etc.), in combination with other aggressive invaders such as whitetop (hoary cress), black henbane, field bindweed, and leafy spurge are increasing in density and frequency, producing their own set of challenging management issues. As more species are found or as other species become more prevalent on a large scale, the community dynamics in this state will shift in response to the concerns of the identified species.

Characteristics and indicators. The Invaded State is characterized by the presence and eventual dominance of invasive and non-native species. The open canopy of the arid native community combined with extended periods of drought alone or in combination with overutilization, insect damage, or wildfire, has weakened the native composition, thus allowing invasion.

Resilience management. The competitive nature of annuals and other invasive species creates a complex environment that inhibits control and makes it implausible to attain complete eradication once an invasive species has established on the landscape.

Community 4.1
Native/Invasive/Sagebrush Plant Community

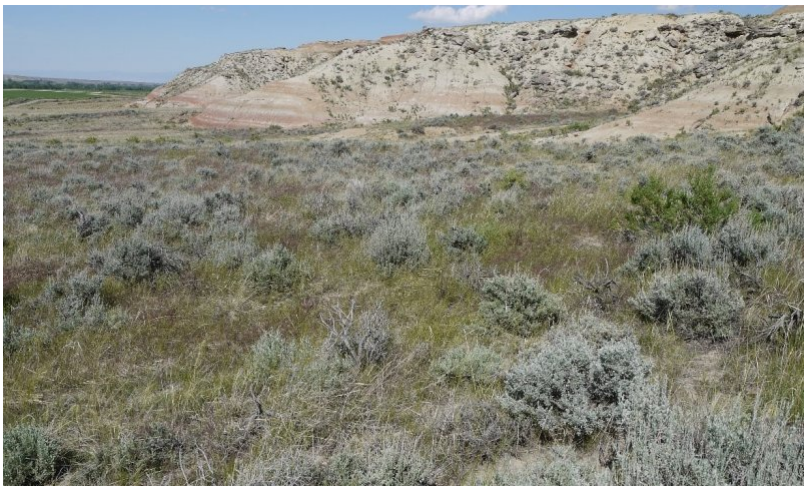


Figure 25. Native grasses and sagebrush an understory of cheatgrass.

The Perennial Grasses/Invasive Species/Wyoming Big Sagebrush Community Phase has maintained a representative composition of native perennial grasses and forbs that are key to this ecological site with the accompanying Wyoming big sagebrush component. Although this community phase is very vulnerable of becoming an invader-driven system, if the invader can be maintained at 5 to 10 percent composition, the probability of the community to persist and possibly improve is retained. However, extent of improvement and exorbitant costs and labor required limit the economic feasibility. Further degradation of this site increases the cost and reduces feasibility of restoring a desired community, which makes this community phase the At-Risk Community. This community phase is characterized by a marked composition of invasive species (5 percent or greater) on the landscape; with a wide-scale distribution, not one isolated patch in an isolated portion of the landscape). The composition still includes a significant native population, and litter has not become inhibiting at this phase in degradation. Production yields of the perennial grasses and forbs are slightly reduced but the total production will maintain or may be slightly elevated due to the overall biomass and expanded growth potential of many of the annual or invasive species. A specific production range is not provided due to the variability of composition that will affect overall production.

Resilience management. Rangeland Health Implications/Indicators: This plant community's susceptibility to fire increases as fine fuels increase with the added biomass and litter produced by invaders (most specific to cheatgrass). Plant diversity is maintained by the remnants of native perennial grasses and shrubs. The plant vigor is diminished, and replacement capabilities are limited due to the reduced cover of cool-season grasses. Limited resources (moisture and nutrients) also inhibits native vigor and persistence in the community. Litter cover and soil erosion for this phase has had minimal to no noticeable change in this community phase. Water flow patterns and pedestalling may be slightly more visible in response to the loss of some native cover. Infiltration is unaltered or slightly reduced; however, as the duff layer or litter builds infiltration and runoff will increase.

Dominant plant species

- Wyoming big sagebrush (*Artemisia tridentata ssp. wyomingensis*), shrub
- needle and thread (*Hesperostipa comata*), grass
- prairie Junegrass (*Koeleria macrantha*), grass
- cheatgrass (*Bromus tectorum*), grass

Community 4.2
Invasive/Sagebrush Plant Community

Community Phase 4.2 is characterized by the existence of sagebrush with only remnant populations of native species and a dominance of invasive species. As the native populations of perennial grasses and forbs are removed through severe use or disturbance, the site becomes invader-driven. Continued environmental- or management-derived impacts to the shrub component places this community at risk of crossing a threshold. Wyoming big sagebrush can compete and maintain a strong community under a heavy infestation level of most invasive species, unless fire or similar disturbance removes the woody cover. The canopy of the sagebrush serves as a protective niche in the system for native grasses and forbs, allowing remnant populations to persist. But the system is low in resistance and even lower in resilience. The fine fuels or biomass produced by cheatgrass and others raises a significant threat of fire and increases the potential frequency of occurrence and intensity. Strategies to control or

manage for invasive species, namely cheatgrass, are the subject of research across the western United States. High-intensity grazing with chemical control and the use of biological agents are techniques that have been given trials with varying levels of success. The key management strategies must be to maintain the remnant populations of native grasses and to reduce the risk of fire to allow the persistence of Wyoming big sagebrush. This will maintain the reduced biotic integrity (maintaining species richness, providing structure and a range of growth traits allowing adaptability of the site to varying climatic swings) and help to support the hydrologic function (providing snow catchment, and shade to allow a slow release of winter precipitation during spring melt, which gives a longer moist season for optimal growth of native species). Each location must be addressed individually to determine the best management strategies to utilize the native species present in the system and to determine the limitations of the resources.

Resilience management. Rangeland Health Implications/Indicators: This plant community is resistant to change in relation to returning to a native dominant system, but as the pressure from invasive species continues, it loses its resistance as it shifts to an invader-only community. These areas may be more prone to fire as fine fuels are more available with increased biomass and plant density as the annual invaders fill interspaces. Plant diversity is poor. The plant vigor is diminished, and adaptability and replacement capabilities are limited due to the reduced number of cool-season grasses. Plant litter is noticeably more when compared to the Reference communities due to the potential biomass produced by the invasive species (species-dependent). Soil erosion is variable depending upon the species of invasion and the litter accumulation thus associated. The variability of the water flow and pedestalling, as well as infiltration and runoff, is determined again by the species that establishes on this site.

Dominant plant species

- Wyoming big sagebrush (*Artemisia tridentata ssp. wyomingensis*), shrub
- cheatgrass (*Bromus tectorum*), grass

Community 4.3
Invasive Plant Community

Downy brome, better known as cheatgrass (*Bromus tectorum*), can green-up and grow late into the fall and green-up early spring before snowmelt; this growth pattern allows cheatgrass to utilize fall and spring resources that are otherwise stored for the cool-season native vegetation before they can begin to break dormancy. The morphology of the seed allows for easy dispersal and longevity, creating a widespread and long-term seed bank. Seeds can persist for long periods of time until growing conditions are optimal, allowing growth before most native species. The ability of the plant to grow quickly, utilizing available resources and producing large quantities of seed rapidly, and to reproduce in poor conditions are what drives cheatgrass above the natives and many improved varieties of grass; as well as creates a management challenge that has not been successfully met at this time. Once this species has a niche on a landscape it is resistant and resilient to change. The absence of sagebrush in this community restricts the potential for native herbaceous species, but some will persist in small scattered populations or sparsely under the canopy of cheatgrass. When climatic conditions are optimal, these resilient native species will respond to the available resources (typically mid-spring moisture). They are not able to out-compete invasive species long-term, so are restricted to a minor composition in the community. The ability for cheatgrass to emerge, bolt, produce seed, and mature two to three times within a year utilizes all available soil nutrients and moisture resources. Chemical control is difficult to attain and maintain success without lasting effects on the native grasses in the area. Chlorosis of wheatgrasses, stunted plants, and loss of certain forbs are a few of the residual chemical effects: plateauing is what has been observed in this region. This generally comes from the chemical composition and its ability to bind to the chemistry or nutrients in the soil, inhibiting the uptake by roots. The risk, frequency and intensity of wildfires increase with the increasing fine fuels (biomass load) created by cheatgrass. The fire frequency interval has been noted to shift to a possible five-year cycle, preventing sagebrush and other woody species from establishing on the site. Negative impacts on many of the native herbaceous species in the understory are intensified by increased evaporation and mineralization or vaporization of many of the nutrients, rendering the soils nearly sterile. The grazing potential is limited due to the unpalatable and harsh environment that the mature seeds create with their long awns and chaff. If grazed in early spring or late fall some of this can be avoided, but general use through the middle of the growing season is difficult and defeats the purpose of intensively grazing the location. In smaller invaded sites or under certain conditions, grazing can be used as a tool within the integrated pest management toolbox, but it is not effective alone.

Resilience management. Rangeland Health Implications/Indicators: This plant community is resistant to change.

Plant diversity is poor. The plant vigor is diminished, and replacement capabilities are non-existent due to the loss of cool-season grasses. Plant litter is noticeably more when compared to Reference communities in response to the dense duff layer created by cheatgrass. Soil erosion generally is reduced in response to the litter accumulation. Infiltration and runoff are variable due to the loss of perennial vegetation, but with the potential increase in root density. Overall biotic integrity is lost in this community.

Dominant plant species

- cheatgrass (*Bromus tectorum*), grass

Pathway CP 4.1-4.2
Community 4.1 to 4.2

Frequent or severe grazing, wildfire, and drought—Drought, wildfire, or other climatic stresses on the system will continue to hinder the native species, reducing their ability to maintain their footprint in the plant community. Wildfire is still rare at this phase, but there is an ever-increasing risk with increasing invasive species cover. Continued stress of frequent or severe grazing pressure from wildlife and livestock can reduce the native composition to an unviable or unsustainable population and allow the invasive species to dominate. Wildlife and livestock will utilize cheatgrass and other invasive species but tends to be during initial spring green-up while natives are still dormant or in the fall after the natives have dried down, but invasive species have a secondary flush of growth. This is more typical in species such as knapweeds, whitetop, and specifically cheatgrass (downy brome).

Pathway CP 4.1-4.3
Community 4.1 to 4.3

Extended periods of frequent or severe grazing and/or drought, or wildfire—A major disturbance that removes sagebrush as well as other native herbaceous species leaves the community vulnerable to invasive species. With the increase in fine fuels created by cheatgrass and other invasive species, the wildlife risk of this community rises and can further transition this site to an invasive-dominated community (near-monoculture). Continued stress of drought or frequent and severe grazing can also further degrade this community, allowing for a complete invasion.

Context dependence. The transition from a sagebrush and native grasses driven state to a invader driven state may occur over a period of time, but generally this transition is related to a catastrophic type event. These events may include a wildfire, mechanical treatment failure, or construction type activities.

Pathway CP 4.2-4.1
Community 4.2 to 4.1

Integrated pest management and weed control and long-term prescribed grazing—Control of invasive species and managing grazing to allow use of the invasive species with minimal impact to the native population, will allow the community to regain or maintain potential. But currently, it is not possible to eradicate the invasive species, and sustained control requires intensive inputs over the course of several years. To maintain the system with no further degradation requires a dual approach with both long-term prescribed grazing and intensive weed management (integrated pest management). No one single practice can sustain this phase, as it requires intensive management to prevent the transition to Community Phase 4.3 – Invaders (Annuals), and to encourage the recovery of native species.

Context dependence. Extent of control and ability of the community to recover (native grasses primarily) is dependent on climatic conditions and the invasive species that has established in the community.

Conservation practices

Range Planting
Integrated Pest Management (IPM)
Upland Wildlife Habitat Management
Native Plant Community Restoration and Management
Prescribed Grazing

Invasive Plant Species Control
Grazing Management Plan
Herbaceous Weed Control

Pathway CP 4.2-4.3
Community 4.2 to 4.3

Catastrophic or extreme grazing and/or drought events, or wildfire—The transition to Community Phase 4.3 can occur with continued extensive use and drought. However, the complete loss of sagebrush generally occurs under a major disturbance (fire, mechanical alteration, chemical means) and establishment of invasive species will become a near-monoculture.

State 5
Altered

The arid nature of this region has played a major role in the development and transitions in land use over time. Early settlers worked to farm any land that was accessible by water (canal systems) and equipment. Many of these small areas were later abandoned and left to return to rangeland. Other landscapes were treated with a variety of prescriptions to manage or eradicate sagebrush. Tillage of the soil, changes in hydrology caused by the loss of vegetative structure, constant natural climatic fluctuations, and advancements in seed sources has led to the creation of a site description for the Altered State. The disturbed or degraded state could be drafted as a stand-alone box within the State-and-Transition Model diagram. No matter how a location is classified, once the site has experienced an event that has altered the soil properties (erosional, depositional, hydrological, or chemical), the site potential is altered. To consider this as an alternate ecological site would not be unreasonable. In some cases (site by site consideration), recorrelation of a location may be the best solution. In many cases, however, the soils have not been altered out of the current site characteristics, but the potential has shifted enough that it is no longer truly comparable to the Reference State (State 1).

Characteristics and indicators. Mechanical, cultural, or natural disturbance to soils resulting in an alteration of structure, hydrologic function, and possibly stability prevent a site from supporting the native vegetation or responding to management in the same way as an undisturbed site. Reclamation or restoration of an area will not replace the original function and factors that made the original location respond as it did. Therefore, these "altered" lands may, after significant inputs and time, resemble the Reference Communities (1.1 or 1.2), but they will not respond or function as the Reference Community.

Resilience management. The species selection, extent or occurrence of tillage, and the resulting loss of structure, moisture, biotic degradation, changes in infiltration and water-holding capacity, and change in permeability are all factors that affect a planted site. The time required and feasibility for the redevelopment of soil, as well as variability in plant establishment and climatic conditions determine the successional path after a disturbance event. Kochia, Russian thistle, and mustards are the typical primary successional species in this LRU. Although they provide organic material, nutrient flow and erosional protection, they lack the structure and root system to fully stabilize the site. With time, the site may become similar in composition to Reference, but the integrity of the soil is altered, changing community potential. To capture the dynamics of this process, an Altered State was added to document these communities that exist on the landscape.

Community 5.1
Disturbed/Degraded Plant Community

Disturbed or degraded lands are characterized by alteration of the soils to a degree that the functionality (erosional, depositional, hydrological, or chemical) and potential of the soils has been impacted. The method and severity of alternation, as well as the spatial extent of the disturbance will determine vegetation response and management needs. Linear disturbances, such as trails and roads, will hold a different risk than patchwork or polygonal disturbances, such as well-pads or parking areas. Small-scale or isolated disturbances (spot fires, prairie dog town) can be just as significant of a risk as a large-scale disturbance (mine lands). Site-specific evaluations need to be completed to determine the level of effect. Variability of the plant composition within this community prohibits the selection of one specific growth curve. Growth curves for seeded locations will vary, especially with the use of non-

native or cultivated species. In the case of an early successional community or naturally recovering system, the growth curve may resemble the pre-disturbed community. For a more accurate growth curve, a site-specific species inventory and documentation of the climatic tendencies should be collected.

Resilience management. Rangeland Health Implications/Indicators: The plant community is variable and, depending upon the age of the stand and the stage of successional tendencies of the location, will determine how stable (resilient/resistant) the community is. Plant diversity of these successional communities generally is strong but is usually lacking in the structural groups that are desired on the site. In areas of new or frequent disturbance, annual weedy species or early successional plants will be the dominant cover, providing a strong diversity, but this community has minimal structural cover for some wildlife. As the site matures or as the period between disturbances is lengthened, perennial or taller-statured, stronger-rooted species will increase providing protection, improves hydrologic processes, and allows establishment of grasses, forbs, and shrubs. This flexibility within the community creates a variable level of biotic integrity. Soil erosion is dependent upon the disturbance regime and the biotic integrity of the community. The variability of the community also affects water flow, infiltration, and runoff, which in turn effects the potential risk for erosion and pedestalling. Other factors that are more prevalent or influential for these sites are surface roughness and brokenness (tire tracks, hoof action, smoothed, denuded surfaces, trails that may focus the water).

Community 5.2
Restored/Reclaimed Plant Community

Improvements in techniques and technology for reclamation practices over the last several decades have altered the success and stability of reclaiming a site. Crested wheatgrass was a species used frequently for reclamation throughout Wyoming. These stands are still present today, and generally are stable as a monoculture until a disturbance creates a niche for other species to establish. In limited areas, there are indications that crested wheatgrass is creeping out into native communities as readily as native species are moving into the crested wheatgrass stands. With time, species such as Russian wildrye and varieties of rhizomatous and bunch-wheatgrasses were added with crested wheatgrass to provide a diversity of longevity and initial establishment. Variability in timing and amount of precipitation in this LRU limits the success of range plantings. However, limited success has been documented along pipeline corridors, well or pad sites, and along transportation corridors. Current interpretations of reclaimed or restored refers to the establishment of native species in a composition as close to a natural (pre-disturbance) plant community as possible. This excludes the use of non-native species. Although native species are used in reclamation, these plantings will not replicate the Reference Community in response to management due to the change in soil dynamics with mechanical disturbance (seedbed preparation and seeding), but they may be similar. The use of native cultivars allows for an ecological response that resembles pre-disturbance closer than a non-native community. The growth curve of this plant community will vary depending upon the species that are selected for the reclamation seed mix. For a more accurate growth curve the species used, and the climatic tendencies of the area specifically must be considered.

Resilience management. Rangeland Health Implications/Indicators: The resistance to change and resiliency of a plant community is determined by the specific seeding mixtures. Success in establishment of this mixture and the conditions of the site will determine the ability to resist against weed infestations as well as the potential for erosion. Many of the seeded communities are diversity-poor. Historic seedings of one or two species limited the resiliency of a site but provided a substantial benefit. The current seeding standards have helped improve these benefits, but are limited by the seed sources available, the ability to prepare and seed the location, and the economics of the planting. Many seeded sites may be prone to fire because of the increased production as they mature (more biomass and possibly more litter), providing abundant fine fuels to carry a fire. Soil erosion is variable depending upon the establishment of the seeding, how it is seeded, and mechanical procedures put in place. The variability of the water flow and pedestalling as well as infiltration and runoff is determined again by the species that comprise the community and the method of seeding (site preparation and seeding practice).

Pathway CP 5.1-5.2
Community 5.1 to 5.2

Seeding, brush management, integrated pest management, prescribed grazing management—Restoration or reclamation of a site to an intended purpose can be achieved with proper mechanical improvements and follow-up maintenance. However, climatic limitations and quality of preparation will determine the success of plantings. Depending upon the location, plantings are slow to establish and risk of (re)invasion by undesirable species creates

a moderately low potential for success. Proper preparation, careful timing, and integrated pest management becomes crucial to allow seeding. Brush management may be required in some disturbed communities to open areas that can readily be seeded.

Context dependence. The type of disturbance that led to the shift from a previous state to this state will determine the further mechanisms required to restore or reclaim this particular community. The successional stage and the species that are establishing will determine the type of land manipulations needed.

Conservation practices

Grazing Land Mechanical Treatment
Range Planting
Heavy Use Area Protection
Integrated Pest Management (IPM)
Upland Wildlife Habitat Management
Early Successional Habitat Development/Management
Livestock Use Area Protection
Native Plant Community Restoration and Management
Invasive Plant Species Control
Grazing Management Plan
Grazing management to improve wildlife habitat
Herbaceous Weed Control

Pathway CP 5.2-5.1
Community 5.2 to 5.1

No use, no fire, long-term prescribed grazing, frequent or severe grazing—Decline in plant vigor and health with lack of use or continuous or severe stress allows for a corresponding shift in composition. The seeded plant community and the altered soil properties from seedbed preparation of general disturbances restricts the responses to management from what would be expected under natural conditions. Monitoring and range trend over time helps to determine if a location is degrading or adjusting with the climatic variables of the site. The initial establishment phase of a reclaimed site is crucial to determine success, but at any stage of a seeding, degradation or further disturbance can occur, forcing the site to phase back to a degraded or disturbed community.

Context dependence. The plant species that established during the restoration/reclamation process, the mechanical means of completing this process, and environmental factors all have a major influence of how this community will or may transition back to.

Transition T 1-2
State 1 to 2

Frequent and severe grazing (year-long) or drought with the absence of brush management or wildfire—The conversion to a Wyoming Big Sagebrush/*Bare Ground* plant community is a response to extended periods of stress, both climate- and human-induced. Frequent or high-intensity herbivory with minimal to no recovery period weakens the ability for the grasses to persist, especially during prolonged drought. With the weakened herbaceous cover, the composition will shift to predominantly Wyoming big sagebrush. Over time sagebrush composition will increase inhibiting the recovery. With added climatic stress, species diversity and productivity are lost, and the community crosses into the Sagebrush/*Bare Ground* State. An illusion of crossing the threshold to State 2 is created in extended periods of significant fluctuation in precipitation patterns affecting production of prominent plants within this system. The loss of species diversity and increased bare ground over a period of years, along with lack of litter are the indicators that a true transition has occurred. It is important to recognize that woody cover is a factor of the number of plants as well as canopy cover. In some instances, the number of actual sagebrush plants may not increase to cause this shift, but the change in composition or vigor of the wood canopy, as well as the loss of herbaceous canopy, creates the perception of an increased number of plants when it is the ratio, size, and age

that is more likely to shift.

Constraints to recovery. Having sufficient key species and cooperation of precipitation and rest from use to allow the native bunchgrasses to re-establish within the interspaces of sagebrush is the main constraint to recovery. Being able to thin while maintaining some woody cover may also be challenging for the recovery process.

Transition T 1-3
State 1 to 3

Frequent grazing (year-long), brush management, or fire with drought—Severe and frequent grazing reduces vigor and presence of key species, mainly needle and thread and Indian ricegrass, and short-statured grasses become dominant. Animal disturbance (hoof impact) and continuous use reduces the bunchgrass component by allowing repeated defoliation of the desirable species and damage to the structure of the plant. These impacts reduce recovery potential and ground cover for insulation and snow catch; weakening and, over time, removing select species. The open canopy and hoof impact encourage species that are tolerant to trampling and short bursts of spring and summer precipitation. These species generally are tillering, mat- or sod-forming species such as blue grama and threadleaf sedge. Prolonged drought stresses the plants and opens the canopy, allowing sod-formers to fill in the interspaces. The shallow, dense root mats will continue to spread over time. The added removal of sagebrush with animal impacts or with fire or brush management may open the canopy more and aid in establishment. Season of use and intensity of grazing (time and timing) are triggers that can reduce the risk of transitioning, or, if done improperly, can force the transition to occur rapidly. The increase in blue grama adds an element of midsummer growth that extends the “green” grazing window. However, adequate amounts and timing of moisture must occur to allow sufficient growth to prevent overuse of the cool-season species.

Constraints to recovery. The ability to weaken or break up the sod-forming species and the lack of remaining native (key) bunchgrasses are the main constraints to recovery for this community.

Context dependence. The time lapse for the occurrence of this state is varied. It is a transition that takes or may take a significant time frame (over ten years) to occur. Recovery may be able to be achieved; but at this time no proof of recovery, without mechanical interference, has been achieved/documented within a management time frame (25 years).

Restoration pathway R 2-1
State 2 to 1

Prescribed grazing with brush management or wildfire—Thinning or patch treatments for sagebrush allow native herbaceous cover to respond to improved moisture and sunlight followed by prescribed grazing to prevent will help this community recover. Treatment will vary depending upon the existing composition of grasses remaining and the potential threats to the location. Removal or thinning of the sagebrush within this community will help to reduce competition, encouraging grasses and forb recovery if the disturbance or overuse (recreational or grazing pressure) is reduced. Drought may prolong the time required for recovery. Mowing or mulching sagebrush trials have shown a strong response by grasses with little to no recovery time post-treatment. The resulting community with these treatments is driven by the dominant species within the community pre-treatment or climatic and treatment conditions during and following may sway the community. It is crucial to investigate the immediate and surrounding area around treatment sites to ensure no invasive species (cheatgrass) are present before treatment type is decided and then applied. The arid climate and lack of fine fuels limits the feasibility of fire as a brush management tool in this system.

Transition T 2-3
State 2 to 3

Drought, Disease or Insect Damage, Over-use, or Fire - Sod-forming species such as blue grama and threadleaf sedge can tolerate high levels of use and will maintain as other native species decline. Hoof action or compaction inhibits more desirable native species, allowing the sod-formers to become dominant on the landscape. This decline creates a sagebrush/sod community that is resistant to change with management. Impacts to sagebrush by disease or insect damage, as well as drought or herbivory, will shift this to the secondary community phase with cactus as a subdominant cover with blue grama.

Constraints to recovery. The hydrologic shift caused by blue grama and the tolerance and resiliency of this species limits the ability to weaken/reduce its foothold in the community enough to encourage the mid-stature bunchgrasses key to this site.

Transition T 2-4
State 2 to 4

Fire (wild), Frequent or Severe Grazing, Drought with Insect Damage/Brush Management – Throughout most of this LRU there is a seed source present for cheatgrass, knapweed, and other invasive species. Stress to the native community from fire, drought, disease/insect damage to sagebrush, or ground/soil disturbance including impacts by grazing large herbivores or recreational uses; opens the canopy and exposes the soil, creating a niche for undesirable and invasive species to establish. Early detection and rapid response provides a chance to prevent a full-scale invasion, but if left untreated, infestations can establish rapidly and spread with one growing season. The population soon grows exponentially as further stress or disturbance occurs. In some cases, once the invasive species are established, they can create their own habitat; this reduces the competitive ability of native species. The open canopy of the Sagebrush/*Bare Ground* State is vulnerable to invasive species without further influence. With continued over-use, drought, or insect damage/disease, the invasive species will establish and quickly dominate a location. The threshold species in this system is Wyoming big sagebrush, which protects the remnants of the perennial native grasses, allowing them to persist on the landscape.

Constraints to recovery. The lack of sufficient key native species and the inability to eradicate or sufficiently control invasive species are the main constraints to recovery for this state.

Context dependence. Extent of the transition for the sagebrush/bare ground state to the invaded state will determine the severity of the recovery constraints. The loss of sagebrush from this state will further limit/remove any ability of this state to recover back to any previous state.

Transition T 3-4
State 3 to 4

Frequent and severe grazing, drought, or disturbance with a seed source present—Increased interspatial gaps in these communities leaves exposed soil that is vulnerable to invasion by undesirable species. Increased pressure from overuse and drought work to weaken the sod or mat-like community, exposing soil further to annuals and other invaders, such as cheatgrass and knapweeds. The aggressive nature and altered hydrology of these sites do restrict weed invasion. But if a seed source is available, ground disturbance by herbivores or man-induced, allows invasive species to find a way into the community. Once established in the community, it may not be feasible to completely remove eradicate the invasive species. Once the invasive species have become prevalent on the landscape (less than 5 percent composition), the community crosses the threshold into the Invaded/Sagebrush State (State 4).

Constraints to recovery. The lack of ability to eradicate or remove invasive species from the community at this time is the constraint to any recover from the invader driven state.

Context dependence. Substantial evidence that a blue grama dominated community has shifted to a invade/sagebrush or invaded community has not been gathered. It has been documented where a significant population of invasive species (ex: cheatgrass) has established within the inter-spaces of the blue grama sod.

Restoration pathway R 4-5
State 4 to 5

Integrated pest management with seeding—Integrated pest management with intense weed control after and possibly before seedbed preparation will be necessary to overcome a severe weed infestation. Working the soil and preparing a seedbed at a location and using improved varieties, native seed, or, in some cases, an introduced species suited for the intended land use may be the only way to overcome some invasive species. Success of reestablishing a native or desired plant community on a large scale is not documented. Small-scale attempts are rated to be low and highly variable for the rate of control of most species. Seedings can be designed to bring this community that is like an at-risk community within the Reference State, but that it is not possible to reach the

Reference Community (1.1) once annuals have established on a site. The limited success of seedings, lack of seed sources for all native species, the possible need to mechanically prepare a seedbed, as well as alternation of soil stability and hydrologic functions inhibit a true Reference restoration for this site. The alteration of the soils, the change in the plant community, and the risk of reinvasion of the site inhibits its ability to react the same to management and environmental changes as a truly native community and so would enter an Altered State.

Context dependence. Species of concern (invasion) will be the determining factor to what processes will need to occur to allow an invaded community to be restored/reclaimed.

Conservation practices

Critical Area Planting
Grazing Land Mechanical Treatment
Range Planting
Heavy Use Area Protection
Integrated Pest Management (IPM)
Upland Wildlife Habitat Management
Early Successional Habitat Development/Management
Livestock Use Area Protection
Planned Grazing System
Native Plant Community Restoration and Management
Prescribed Grazing
Invasive Plant Species Control
Grazing Management Plan
Herbaceous Weed Control

Transition T 5-4
State 5 to 4

No use, fire (wild or prescribed), frequent or severe grazing, drought with seed source present—Lack of management to prevent a repeat of a specific disturbance or the absence of use following the reclamation or restoration process will cause the community to revert or transition to an invaded state. Wildfire, prescribed burning, drought, or frequent and severe use by large herbivores can be disturbances that either opens the canopy or introduces the species to the location. Extended periods of non-use create a decadent community with a large proportion of dead growth persisting around the crown of the plants, reducing vigor and production. As the plants begin to recede, the community becomes vulnerable to weed invasions. Frequent or severe grazing, drought, or fire can open the canopy to and assist with the incorporation of seed sources encouraging an invasion as well. This invasion triggers the transition to an Invaded State.

Constraints to recovery. The species of invasion is the major constraint to recovery. Eradication has been unsuccessful for most of the major species affecting these communities on a large scale.

Additional community tables

Table 25. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**Mid-stature, Cool-season Bunchgrass**			180–320	
	needle and thread	HECO26	*Hesperostipa comata*	120–200	30–50
	Indian ricegrass	ACHY	*Achnatherum hymenoides*	40–80	10–20
	bluebunch wheatgrass	PSSP6	*Pseudoroegneria spicata*	20–40	5–10
2	**Rhizomatous, Cool-season Grasses**			20–60	
	thickspike wheatgrass	ELLAL	*Elymus lanceolatus ssp. lanceolatus*	20–60	5–10
	western wheatgrass	PASM	*Pascopyrum smithii*	0–60	5–10
3	**Short-stature, Cool-season Bunchgrass**			20–60	
	prairie Junegrass	KOMA	*Koeleria macrantha*	20–40	5–10
	Sandberg bluegrass	POSE	*Poa secunda*	0–20	0–5
	squirreltail	ELEL5	*Elymus elymoides*	0–20	0–5
4	**Mid-stature, Warm-season Bunchgrass**			0–20	
	threeawn	ARIST	*Aristida*	0–20	0–5
	sand dropseed	SPCR	*Sporobolus cryptandrus*	0–20	0–5
5	**Short-stature, Warm-season Tillering Grass**			0–20	
	blue grama	BOGR2	*Bouteloua gracilis*	0–20	0–5
6	**Miscellaneous Grass/Grass-like**			0–20	
	threadleaf sedge	CAFI	*Carex filifolia*	0–20	0–5
	Grass, perennial	2GP	*Grass, perennial*	0–20	0–5
Forb					
7	**Perennial Forbs**			20–60	
	sandwort	ARENA	*Arenaria*	0–20	0–5
	fleabane	ERIGE2	*Erigeron*	0–20	0–5
	desertparsley	LOMAT	*Lomatium*	0–20	0–5
	spiny phlox	PHHO	*Phlox hoodii*	0–20	0–5
	granite prickly phlox	LIPU11	*Linanthus pungens*	0–20	0–5
	scarlet globemallow	SPCO	*Sphaeralcea coccinea*	0–20	0–5
	little larkspur	DEBI	*Delphinium bicolor*	0–20	0–5
	plains pricklypear	OPPO	*Opuntia polyacantha*	0–20	0–5
	scarlet beeblossom	GACO5	*Gaura coccinea*	0–20	0–5
	Forb, perennial	2FP	*Forb, perennial*	0–20	0–5
Shrub/Vine					
8	**Dominant Shrub**			20–60	
	Wyoming big sagebrush	ARTRW8	*Artemisia tridentata ssp. wyomingensis*	20–60	5–15
9	**Miscellaneous Shrubs**			0–40	
	winterfat	KRLA2	*Krascheninnikovia lanata*	0–20	0–5
	yellow rabbitbrush	CHVI8	*Chrysothamnus viscidiflorus*	0–20	0–5
	rubber rabbitbrush	ERNA10	*Ericameria nauseosa*	0–20	0–5
	fourwing saltbush	ATCA2	*Atriplex canescens*	0–20	0–5
	spiny hopsage	GRSP	*Grayia spinosa*	0–20	0–5

Table 26. Community 1.2 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**Mid-stature, Cool-season Bunchgrass**			75–160	
	needle and thread	HECO26	*Hesperostipa comata*	75–100	20–30
	Indian ricegrass	ACHY	*Achnatherum hymenoides*	0–40	0–10
	bluebunch wheatgrass	PSSP6	*Pseudoroegneria spicata*	0–20	0–5
2	**Rhizomatous, Cool-season Grasses**			20–60	
	thickspike wheatgrass	ELLAL	*Elymus lanceolatus ssp. lanceolatus*	20–60	5–10
	western wheatgrass	PASM	*Pascopyrum smithii*	0–60	0–10
3	**Short-stature, Cool-season Bunchgrass**			0–60	
	prairie Junegrass	KOMA	*Koeleria macrantha*	0–40	0–10
	Sandberg bluegrass	POSE	*Poa secunda*	0–20	0–5
	squirreltail	ELEL5	*Elymus elymoides*	0–20	0–5
4	**Mid-stature, Warm-season Bunchgrass**			0–20	
	threeawn	ARIST	*Aristida*	0–20	0–5
	sand dropseed	SPCR	*Sporobolus cryptandrus*	0–20	0–5
5	**Short-stature, Warm-season Tillering-grasses**			20–40	
	blue grama	BOGR2	*Bouteloua gracilis*	20–40	5–10
6	**Miscellaneous Grass and Grass-likes**			0–40	
	threadleaf sedge	CAFI	*Carex filifolia*	0–20	0–5
	Grass, perennial	2GP	*Grass, perennial*	0–20	0–5
Forb					
7	**Perennial Forbs**			5–80	
	sandwort	ARENA	*Arenaria*	0–20	0–5
	fleabane	ERIGE2	*Erigeron*	0–20	0–5
	desertparsley	LOMAT	*Lomatium*	0–20	0–5
	spiny phlox	PHHO	*Phlox hoodii*	0–20	0–5
	granite prickly phlox	LIPU11	*Linanthus pungens*	0–20	0–5
	scarlet globemallow	SPCO	*Sphaeralcea coccinea*	0–20	0–5
	little larkspur	DEBI	*Delphinium bicolor*	0–20	0–5
	plains pricklypear	OPPO	*Opuntia polyacantha*	0–20	0–5
	scarlet beeblossom	GACO5	*Gaura coccinea*	0–20	0–5
	Forb, perennial	2FP	*Forb, perennial*	0–20	0–5
8	**Annual Forbs**			0–10	
	woolly plantain	PLPA2	*Plantago patagonica*	0–10	0–5
	Forb, annual	2FA	*Forb, annual*	0–10	0–5
Shrub/Vine					
9	**Dominant Shrubs**			20–200	
	Wyoming big sagebrush	ARTRW8	*Artemisia tridentata ssp. wyomingensis*	20–100	5–25
10	**Miscellaneous Shrubs**			20–40	
	winterfat	KRLA2	*Krascheninnikovia lanata*	0–20	0–5

	yellow rabbitbrush	CHVI8	*Chrysothamnus viscidiflorus*	0–20	0–5
	rubber rabbitbrush	ERNA10	*Ericameria nauseosa*	0–20	0–5
	fourwing saltbush	ATCA2	*Atriplex canescens*	0–20	0–5
	spiny hopsage	GRSP	*Grayia spinosa*	0–20	0–5

Table 27. Community 2.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**Mid-stature, Cool-season Bunchgrass**			20–100	
	needle and thread	HECO26	*Hesperostipa comata*	20–80	5–20
	Indian ricegrass	ACHY	*Achnatherum hymenoides*	0–20	0–5
	bluebunch wheatgrass	PSSP6	*Pseudoroegneria spicata*	0–20	0–5
2	**Rhizomatous, Cool-season Grasses**			20–80	
	thickspike wheatgrass	ELLAL	*Elymus lanceolatus ssp. lanceolatus*	20–80	5–20
	western wheatgrass	PASM	*Pascopyrum smithii*	0–80	0–20
3	**Short-stature, Cool-season Bunchgrass**			0–40	
	squirreltail	ELEL5	*Elymus elymoides*	0–20	0–5
	prairie Junegrass	KOMA	*Koeleria macrantha*	0–20	0–5
	Sandberg bluegrass	POSE	*Poa secunda*	0–20	0–5
4	**Mid-stature, Warm-season Bunchgrass**			0–20	
	threeawn	ARIST	*Aristida*	0–20	0–5
	sand dropseed	SPCR	*Sporobolus cryptandrus*	0–20	0–5
5	**Short-stature, Warm-season Tillering-grasses**			5–40	
	blue grama	BOGR2	*Bouteloua gracilis*	5–40	1–10
6	**Miscellaneous Grass and Grass-likes**			0–60	
	threadleaf sedge	CAFI	*Carex filifolia*	5–40	1–10
	Grass, perennial	2GP	*Grass, perennial*	0–20	0–5
	Grass, annual	2GA	*Grass, annual*	0–20	0–5
Forb					
7	**Perennial Forbs**			5–60	
	plains pricklypear	OPPO	*Opuntia polyacantha*	0–40	0–10
	scarlet beeblossom	GACO5	*Gaura coccinea*	0–20	0–5
	Forb, perennial	2FP	*Forb, perennial*	0–20	0–5
	sandwort	ARENA	*Arenaria*	0–20	0–5
	fleabane	ERIGE2	*Erigeron*	0–20	0–5
	desertparsley	LOMAT	*Lomatium*	0–20	0–5
	spiny phlox	PHHO	*Phlox hoodii*	0–20	0–5
	granite prickly phlox	LIPU11	*Linanthus pungens*	0–20	0–5
	scarlet globemallow	SPCO	*Sphaeralcea coccinea*	0–20	0–5
	little larkspur	DEBI	*Delphinium bicolor*	0–20	0–5
8	**Annual Forbs**			0–40	
	woolly plantain	PLPA2	*Plantago patagonica*	0–10	0–5
	Forb, annual	2FA	*Forb, annual*	0–10	0–5

Shrub/Vine					
9	**Dominant Shrubs**			40–200	
	Wyoming big sagebrush	ARTRW8	*Artemisia tridentata ssp. wyomingensis*	40–200	10–40
10	**Miscellaneous Shrubs**			10–50	
	winterfat	KRLA2	*Krascheninnikovia lanata*	0–20	0–5
	yellow rabbitbrush	CHVI8	*Chrysothamnus viscidiflorus*	0–20	0–5
	rubber rabbitbrush	ERNA10	*Ericameria nauseosa*	0–20	0–5
	fourwing saltbush	ATCA2	*Atriplex canescens*	0–20	0–5
	spiny hopsage	GRSP	*Grayia spinosa*	0–20	0–5

Table 28. Community 3.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**Mid-stature, Cool-season Bunchgrass**			5–60	
	needle and thread	HECO26	*Hesperostipa comata*	5–40	2–10
	Indian ricegrass	ACHY	*Achnatherum hymenoides*	0–20	0–5
2	**Rhizomatous, Cool-season Grasses**			0–20	
	thickspike wheatgrass	ELLAL	*Elymus lanceolatus ssp. lanceolatus*	0–20	0–5
	western wheatgrass	PASM	*Pascopyrum smithii*	0–20	0–5
3	**Short-stature, Cool-season Bunchgrass**			0–40	
	squirreltail	ELEL5	*Elymus elymoides*	0–20	0–5
	prairie Junegrass	KOMA	*Koeleria macrantha*	0–20	0–5
	Sandberg bluegrass	POSE	*Poa secunda*	0–20	0–5
4	**Mid-stature, Warm-season Bunchgrass**			0–20	
	threeawn	ARIST	*Aristida*	0–20	0–5
	sand dropseed	SPCR	*Sporobolus cryptandrus*	0–20	0–5
5	**Short-stature, Warm-season Tillering-grasses**			40–120	
	blue grama	BOGR2	*Bouteloua gracilis*	40–120	20–60
6	**Miscellaneous Grass and Grass-likes**			5–40	
	threadleaf sedge	CAFI	*Carex filifolia*	5–40	5–20
	Grass, perennial	2GP	*Grass, perennial*	0–20	0–5
	Grass, annual	2GA	*Grass, annual*	0–20	0–5
Forb					
7	**Perennial Forbs**			5–40	
	plains pricklypear	OPPO	*Opuntia polyacantha*	0–40	0–10
	scarlet beeblossom	GACO5	*Gaura coccinea*	0–20	0–5
	Forb, perennial	2FP	*Forb, perennial*	0–20	0–5
	sandwort	ARENA	*Arenaria*	0–20	0–5
	fleabane	ERIGE2	*Erigeron*	0–20	0–5
	desertparsley	LOMAT	*Lomatium*	0–20	0–5
	spiny phlox	PHHO	*Phlox hoodii*	0–20	0–5
	granite prickly phlox	LIPU11	*Linanthus pungens*	0–20	0–5
	scarlet globemallow	SPCO	*Sphaeralcea coccinea*	0–20	0–5

	little larkspur	DEBI	*Delphinium bicolor*	0–20	0–5
8	**Annual Forbs**			0–20	
	woolly plantain	PLPA2	*Plantago patagonica*	0–10	0–5
	Forb, annual	2FA	*Forb, annual*	0–10	0–5
Shrub/Vine					
9	**Dominant Shrubs**			20–60	
	Wyoming big sagebrush	ARTRW8	*Artemisia tridentata ssp. wyomingensis*	20–40	5–10
10	**Miscellaneous Shrubs**			0–40	
	winterfat	KRLA2	*Krascheninnikovia lanata*	0–20	0–5
	yellow rabbitbrush	CHVI8	*Chrysothamnus viscidiflorus*	0–20	0–5
	rubber rabbitbrush	ERNA10	*Ericameria nauseosa*	0–20	0–5
	fourwing saltbush	ATCA2	*Atriplex canescens*	0–20	0–5
	spiny hopsage	GRSP	*Grayia spinosa*	0–20	0–5

Table 29. Community 3.2 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**Mid-stature, Cool-season Bunchgrass**			0–40	
	needle and thread	HECO26	*Hesperostipa comata*	0–40	0–10
	Indian ricegrass	ACHY	*Achnatherum hymenoides*	0–20	0–5
2	**Rhizomatous, Cool-season Grasses**			0–20	
	thickspike wheatgrass	ELLAL	*Elymus lanceolatus ssp. lanceolatus*	0–20	0–5
	western wheatgrass	PASM	*Pascopyrum smithii*	0–20	0–5
3	**Short-stature, Cool-season Bunchgrass**			0–20	
	squirreltail	ELEL5	*Elymus elymoides*	0–20	0–5
	prairie Junegrass	KOMA	*Koeleria macrantha*	0–20	0–5
	Sandberg bluegrass	POSE	*Poa secunda*	0–20	0–5
4	**Mid-stature, Warm-season Bunchgrass**			0–20	
	threeawn	ARIST	*Aristida*	0–20	0–5
	sand dropseed	SPCR	*Sporobolus cryptandrus*	0–20	0–5
5	**Short-stature, Warm-season Tillering-grasses**			40–120	
	blue grama	BOGR2	*Bouteloua gracilis*	40–120	20–60
6	**Miscellaneous Grass and Grass-likes**			5–40	
	threadleaf sedge	CAFI	*Carex filifolia*	5–40	5–20
	Grass, perennial	2GP	*Grass, perennial*	0–20	0–5
	Grass, annual	2GA	*Grass, annual*	0–20	0–5
Forb					
7	**Perennial Forbs**			20–100	
	plains pricklypear	OPPO	*Opuntia polyacantha*	20–100	5–25
	scarlet beeblossom	GACO5	*Gaura coccinea*	0–20	0–5
	Forb, perennial	2FP	*Forb, perennial*	0–20	0–5
	sandwort	ARENA	*Arenaria*	0–20	0–5
	fleabane	ERIGE2	*Erigeron*	0–20	0–5

	desertparsley	LOMAT	*Lomatium*	0–20	0–5
	spiny phlox	PHHO	*Phlox hoodii*	0–20	0–5
	granite prickly phlox	LIPU11	*Linanthus pungens*	0–20	0–5
	scarlet globemallow	SPCO	*Sphaeralcea coccinea*	0–20	0–5
	little larkspur	DEBI	*Delphinium bicolor*	0–20	0–5
8	**Annual Forbs**			0–20	
	woolly plantain	PLPA2	*Plantago patagonica*	0–10	0–5
	Forb, annual	2FA	*Forb, annual*	0–10	0–5
Shrub/Vine					
9	**Dominant Shrubs**			0–20	
	Wyoming big sagebrush	ARTRW8	*Artemisia tridentata ssp. wyomingensis*	0–20	0–20
10	**Miscellaneous Shrubs**			0–20	
	winterfat	KRLA2	*Krascheninnikovia lanata*	0–20	0–5
	yellow rabbitbrush	CHVI8	*Chrysothamnus viscidiflorus*	0–20	0–5
	rubber rabbitbrush	ERNA10	*Ericameria nauseosa*	0–20	0–5
	fourwing saltbush	ATCA2	*Atriplex canescens*	0–20	0–5
	spiny hopsage	GRSP	*Grayia spinosa*	0–20	0–5

Animal community

Animal Community – Wildlife Interpretations:

1.1 – Needle and Thread/Indian Ricegrass (Reference Community): The predominance of grasses in this plant community favors grazers and mixed-feeders, such as bison, elk, and antelope. Suitable thermal and escape cover for deer may be limited due to the low quantities of woody plants. However, topographical variations could provide some escape cover. When found adjacent to sagebrush-dominated states (1.2 or 3.1), this plant community provides brood-rearing and foraging areas for sage grouse, as well as lek sites. The mosaic pattern of varying density of sagebrush in a smaller scale provides cover and line-of-sight to forage. Other birds that would frequent this plant community include western meadowlarks, horned larks, and golden eagles. Many grassland-obligate small mammals would occur here.

1.2 - Perennial Native Grasses/Wyoming Big Sagebrush (At-Risk Community): The predominance of grasses in this plant community favors grazers and mixed-feeders, such as bison, elk, and antelope. Suitable thermal and escape cover for deer may be limited due to the low quantities of woody plants. However, topographical variations could provide some escape cover. This plant community provides brood rearing and foraging areas for sage grouse, as well as lek sites. The mosaic pattern of varying density of sagebrush in a smaller scale provides cover and line of sight to forage. Other birds that would frequent this plant community include western meadowlarks, horned larks, and golden eagles. Many grassland-obligate small mammals would occur here.

2.1 - Mixed Shrub/*Bare Ground* Plant Community: This plant community can provide important winter foraging for elk, mule deer, and antelope, as sagebrush can approach 15 percent protein and 40-60 percent digestibility during that time. This community provides excellent escape and thermal cover for large ungulates, as well as nesting habitat for sage grouse.

3.1 - Sod-formers/Wyoming Big Sagebrush Plant Community: This community provides limited foraging for antelope and other grazers. They may be used as a foraging site by sage grouse where Reference State Community Phases are limited. Generally, these are not target plant communities for wildlife habitat management.

3.2 - Sod-formers/Cactus Plant Community: This community provides limited foraging for antelope and other grazers. They may be used as a foraging site by sage grouse if proximal to woody cover and if the Reference Plant

Community or the Rhizomatous Wheatgrasses/Perennial Grasses/Sod-formers/Wyoming Big Sagebrush Plant Community are limited. Generally, these are not target plant communities for wildlife habitat management.

4.1 - Native Grasses/Invasive Species/Wyoming Big Sagebrush Plant Community: The retained combination of sagebrush and the added diversity with the invasive grasses and forbs provide an extended plant community for wildlife. The similarities to Community Phase 1.2 (Perennial Native Grasses/Wyoming Big Sagebrush) are to some extent enhanced for some species with the added forage provided by the invasive species. However, as the invasive species increase, decreasing the desirable species, the wildlife species benefits are decreased as well.

4.2 - Invasive Species/Wyoming Big Sagebrush Plant Community: Limited nesting and cover is provided by the existing overstory cover of the Wyoming big sagebrush.

4.3 - Invaded (Annuals) Grasses Plant Community: Early spring and fall green-up of cheatgrass provides foraging opportunities for many of our grazers and mixed feeders.

5.1 - Disturbed/Degraded Lands Plant Community and 5.2—Restored/Reclaimed Lands Plant Community: The variability of this site prevents a detailed review of wildlife benefits. However, many of the introduced grasses, forbs, and shrubs can provide adequate cover, food, and nesting sites for those wildlife species that would have selected the site prior to disturbance. Limitations and enhancements should be considered by specific locations.

Animal Community – Grazing Interpretations:

The following table lists suggested stocking rates for cattle under continuous season-long grazing with normal growing conditions. These are conservative estimates that should be used only as guidelines in the initial stages of the conservation planning process. Often, the current plant composition does not entirely match any particular plant community (as described in this ecological site description). Because of this, a field visit is recommended in all cases, to document plant composition and production. More precise carrying capacity estimates should eventually be calculated using this information along with animal preference data, particularly when grazers other than cattle are involved. Under more intensive grazing management, improved harvest efficiencies can result in an increased carrying capacity. If distribution problems occur, stocking rates must be reduced to maintain plant health and vigor.

Plant Community Production Carrying Capacity*

The carrying capacity is calculated as the production (normal year) X .25 efficiency factor / 912.5 # / AUM (Animal Unit Month: the amount of forage required by one mature cow of approximately 1,000 pounds weight, with or without a calf, for one month) to calculate the AUMs/Acre.

Plant Community Description/Title	Lbs./Acre			AUM's/Acre*	Acres/AUM
	Below Ave.	Normal	Above Ave.		
1.1 Needleandthread/Indian Ricegrass	225	400	600	0.11	9.09
1.2 Perennial Native Grasses/Wyoming Big Sagebrush	180	320	480	0.09	11.11
2.1 Mixed Shrubs/*Bare Ground*	200	300	450	0.08	12.50
3.1 Sod-formers/Wyoming Big Sagebrush	60	150	300	0.04	25.00
3.2 Sod-formers/Cactus	55	175	350	0.05	20.00
4.1 Native/Invasive/Wyoming Big Sagebrush	**	**	**	**	**
4.2 Invaded/Wyoming Big Sagebrush	**	**	**	**	**
4.3 Invaded	**	**	**	**	**
5.1 Disturbed/Degraded	**	**	**	**	**
5.2 Restored/Reclaimed	**	**	**	**	**

* - Carrying capacity is figured for continuous, season-long grazing by cattle under average growing conditions.
** - Sufficient data for invaded and reclaimed communities has not be collected or evaluated, at this time, so no projection of a stocking rate recommendation or production range will be established at this time.

Grazing by domestic livestock is one of the major income-producing industries in the area. Rangeland in this area may provide year-long forage for cattle, sheep, or horses. During the dormant period, the forage for livestock use needs to be supplemented with protein because the quality does not meet minimum livestock requirements.

Distance to water, shrub density, and slope can affect carrying capacity (grazing capacity) within a management unit. Adjustments should be made for the area that is considered necessary for reduction of animal numbers. For example, 30 percent of a management unit may have 25 percent slopes and distances of greater than one mile from water; therefore, the adjustment is only calculated for 30 percent of the unit (i.e. 50 percent reduction on 30 percent of the management unit).

Fencing, slope length, management, access, terrain, kind and class of livestock, and breeds are all factors that can increase or decrease the percent of graze-able acres within a management unit. Adjustments should be made that incorporate these factors when calculating stocking rates.

Hydrological functions

Water (time and timing of precipitation) is the principal factor limiting forage production on this site. The Sandy ecological site is dominated by soils in hydrologic group B, with localized areas in hydrologic group C. Infiltration potential for this site varies from moderately rapid to rapid depending upon soil hydrologic group and ground cover. Runoff varies from low to moderate. In many cases, areas with greater than 75 percent ground cover have the greatest potential for high infiltration and lower runoff. An example of an exception would be where short-grasses form a strong sod and dominate the site. Areas where ground cover is less than 50 percent have the greatest potential to have reduced infiltration and higher runoff (refer to Part 630, NRCS National Engineering Handbook for detailed hydrology information).

Rills and gullies should not typically be present. Water flow patterns should be barely distinguishable if at all present. Pedestals are only slightly present in association with bunchgrasses. Litter typically falls in place, and signs of movement are not common. Chemical and physical crusts are rare to non- existent. Cryptogrammic crusts are present, but only cover 1-2 percent of the soil surface.

Recreational uses

This site provides hunting opportunities for upland game species. The wide varieties of plants which bloom from spring until fall have an aesthetic value that appeals to visitors. Outside of plants, the extent offers a variety of cultural resources to view on the landscape based on the location of many of these sites on higher ground on the benches and fans which also provides a rich source of geology for exploration. The extent of this ecological site is found within the Boysen State Park and the Wind River Indian Reservation. These entities have served to protect and provide cultural significance to this ecological site. The Sandy ecological site has minimal limitations when associated with roadways and trails, and provides a sound base for travel and camping in relation to erosion potential and functionality.

Wood products

No appreciable wood products are present on the site.

Other products

Herbs: The forb species of the Sandy ecological site have medicinal characteristics and have been used by the Native Americans in this area and more recently by the naturopathic profession.

Ornamental Species: The forbs commonly found as well as the shrub component of these communities have been used in landscaping and xeriscaping.

Rare and Sensitive Species:
Oryzopsis contracta – Contracted ricegrass (also known as Wyoming ricegrass) was listed as a sensitive or species of concern in 1994, however, this species is not found on the sensitive species lists updated in 2012. This plant is found along the dry sandy soils of this ecological site. It is very similar in appearance to Indian ricegrass (Oryzopsis hymenoides, currently listed as achnatherum hymenoides). It was found that this species was being misidentified regularly for A. hymenoides. But is a sensitive “decreaser” with grazing pressure and disturbance. Species accounts were made in the Big Horn Basin, but a higher occurrence was seen in Wind River Basin and in the foothills.
Ericameria discoidea var. linearis – Whitestem goldenbush is a shrub that is found along the sandy and gravelly

bars of dry floodplains, stream terraces along with sagebrush and up into the forested sites. This shrub is not a preferred browse species by wildlife and is mostly disturbed by recreation.

Inventory data references

Information presented in the original site description was derived from NRCS inventory data. Field observations from range-trained personnel also were used. Those involved in developing the original site include Chris Krassin, Range Management Specialist, NRCS and Everet Bainter, Range Management Specialist. Other sources used as references include USDA NRCS Water and Climate Center, USDA NRCS National Range and Pasture Handbook, USDI and USDA Interpreting Indicators of Rangeland Health Version 3, and USDA NRCS Soil Surveys from various counties.

Those involved in the development of the new concept for the Sandy ecological site include Tricia Hatle, Range Management Specialist, US Department of the Interior-Bureau of Land Management (USDI-BLM); Karen Hepp, Range Management Specialist, USDI-BLM; and Marji Patz, Ecological Site Specialist, NRCS.

Quality control and quality assurance completed by NRCS: Dan Mattke, Area Resource Soil Scientist; Daniel Wood, MLRA Soil Survey Leader; John Hartung, Wyoming State Rangeland Management Specialist; James Bauchert, Wyoming State Soil Scientist; and Scott Woodall, Regional Quality Assurance Ecological Site Specialist.

For specific data inquiries, contact the Powell, Wyoming Soil Survey Office (USDA-NRCS).

Inventory Data References:
Ocular field estimations observed by trained personnel were completed at each site. Then sites were selected where a 100-feet tape was stretched, and the following sample procedures were completed by inventory staff. For full sampling protocol and guidelines with forms please refer to the Wyoming ESI Operating Procedures, compiled in 2012 for the Powell and Rock Springs Soil Survey Office, USDA-NRCS.
• Double Sampling Production Data (9.6 hoop used to estimate 10 points, clipped a minimum of three of these estimated points, with two 21-foot X 21-foot square extended shrub plots).
• Line Point Intercept (overstory and understory captured with soil cover). Height of herbaceous and woody cover is collected every three feet along established transect.)
• Continuous Line Intercept (Woody Canopy Cover, with minimum gap of 0.2 foot for all woody species and succulents. Intercept height collected at each measurement.),
• Gap Intercept (Basal Gap measured with a minimum gap requirement of 0.7 foot.),
• Sample Point (Ten 1-meter square point photographs taken at set distances on transect. Read using the sample point computer program established by the High Plains Agricultural Research Center, WY).
• Soil Stability (Slake Test – surface and subsurface samples collected and processed according to the soil stability guidelines provided by the Jornada Research Center, NM.)

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Approval

Scott Woodall, 9/03/2019

Rangeland health reference sheet

Interpreting Indicators of Rangeland Health is a qualitative assessment protocol used to determine ecosystem condition based on benchmark characteristics described in the Reference Sheet. A suite of 17 (or more) indicators are typically considered in an assessment. The ecological site(s) representative of an assessment location must be known prior to applying the protocol and must be verified based on soils and climate. Current plant community cannot be used to identify the ecological site.

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Date	01/09/2019
Approved by	Marji Patz
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

1. **Number and extent of rills:** Rare to nonexistent. Where present, short and widely spaced.

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2. **Presence of water flow patterns:** Barely observable.

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3. **Number and height of erosional pedestals or terracettes:** Rare to nonexistent.

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4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** Bare ground can range from 25-35%.

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5. **Number of gullies and erosion associated with gullies:** Active gullies should not be present.

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6. **Extent of wind scoured, blowouts and/or depositional areas:** Rare to nonexistent.

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7. **Amount of litter movement (describe size and distance expected to travel):** Herbaceous litter expected to move only in small amounts (to leeward side of shrubs). Large woody debris from sagebrush will show no movement.

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8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):** Soil Stability Index ratings range from 1 (interspaces) to 6 (under plant canopy), but average values should be 5.0 or greater.

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9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):** Refer to soil series description and map unit information for specific information. Described A-horizons vary from 1-4 inches (3-10 cm) with OM of 1 to 2%.

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10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** Evenly distributed plant canopy (35-55%) and litter plus moderate to moderately rapid infiltration rates result in minimal runoff. Basal cover is typically less than 8% for this site and does very little to effect runoff on this site. Canopy cover is sufficient to reduce raindrop impact.

11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):** No compaction of soil surface crusting should be present.

12. **Functional/Structural Groups (list in order of descending dominance by above-ground annual-production or live foliar cover using symbols: >>, >, = to indicate much greater than, greater than, and equal to):**

    Dominant: Cool-season, mid-stature grasses >>

    Sub-dominant: Sub-dominant: perennial shrubs >

    Other: Short stature grasses/grass-likes > Forbs

    Additional:

13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** Minimal decadence, typically associated with shrub component of the canopy cover.

14. **Average percent litter cover (%) and depth (in):** Litter ranges from 20-30% of total canopy measurement with total litter (including beneath the plant canopy) from 30-70% expected. Herbaceous litter depth typically ranges from 3-7 mm. Woody litter can be up to 2 inches (2-5 cm).

15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):** English: 225 - 600 lbs./ac (400 lbs./ac average); Metric: 252 - 673 kg/ha (448 kg/ha average).

16. **Potential invasive (including noxious) species (native and non-native). List species which BOTH characterize degraded states and have the potential to become a dominant or co-dominant species on the ecological site if their future establishment and growth is not actively controlled by management interventions. Species that become dominant for only one to several years (e.g., short-term response to drought or wildfire) are not invasive plants. Note that unlike other indicators, we are describing what is NOT expected in the reference state for the ecological site:** The increase of bare ground above 35% is an indicator that a threshold is being crossed. Corresponding increase will be noted in one or more of the following species is common: blue grama, Sandberg bluegrass, threadleaf sedge, Fendler threeawn, fringed sagewort, pricklypear cactus, Wyoming big sagebrush, and broom snakeweed. Annual weeds such as kochia, mustards, lambsquarter s, Russian thistle, and pepperweed are common invasive species in disturbed sites. Common noxious weeds that invade are: cheatgrass (downy brome), knapweeds, whitetop and others found on the Noxious Weed List for Wyoming and specific counties (Big Horn, Hot Springs, Park, and Hot springs, Wyoming; and Carbon County, Montana).

17. **Perennial plant reproductive capability:** All species are capable of reproducing, except in drought years.